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Biological, Taxonomic and Faunistic Studies on the Shield-Back Katydids of the North American Deserts

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The purpose of this paper is to present what is known concerning the Biology, Taxonomy and Faunistics of the Decticids or Shield-Back Katydids of the North American Deserts. At the same time, an attempt will be made to define and characterize the North American Deserts.

The material presented in these pages to follow, results from the writer's numerous trips and expeditions to the Desert regions during the period 1928 to 1940. What is given on the biology of these rare creatures comes largely from first-hand knowledge, although it is admitted that much is to be ascertained still about the particular life history of each species. Many species of Decticids are so rare that only a single specimen or two is to be found in the museums of North America.

Desert Studies

The Desert of Lower California is the only one of the North American Desert that has not been visited by the writer. During the period 1928 to 1930, the writer studied Chihuahuan Desert of the Big Bend Region of Trans-Pecos Texas while stationed at Presidio, Texas. Later during the summers of 1930 and 1931, the writer, as field collector for Mr. Morgan Hebard of the Academy of Natural Sciences of Philadelphia, collected in southwestern Texas, New Mexico, Arizona, California, Nevada and Utah. Five new Decticids were taken on these trips and these were described by Mr. Hebard in the spring of 1934. Again in 1938, the writer, accompanied by his brother, conducted a private trip to Washington, Oregon, California, Nevada and Arizona. In October, 1939, a journey was made through northwestern Arizona, southern Nevada, Death Valley, the Panamints, Funeral and Inyo ranges to the high Sierra Nevadas of California and in November another excursion carried the author far south into the Mexican state of Sonora. The spring and summer of 1940 was spent in the Arizona deserts and in early August, Dr. Forrest Shreve and the writer embarked on an expedition to northeastern Mexico. Large tracts of virgin desert in southern Coahuila, northern Zacatecas, northern San Luis Potosi and southwestern Nuevo Leon were explored and the eastern limits of the Chihuahuan Desert fixed for the first time in this unknown area. The southern boundary of the Chihuahuan or Eastern Desert tract in the heart of Mexico remains unexplored.

Characteristics of the Desert

The North American Deserts are considered as belonging to the lower Sonoran Faunal Region of the Zoogeographers. They all possess a certain daily temperature range fluctuating between a high diurnal maximum that often reaches 125 degrees Fahrenheit and a lower nocturnal minimum coming just before the dawn. Because the vegetation is sparse and the desert pavement bare the temperature often drops rapidly following sundown, especially during the winter months. Some deserts such as the Sahara and the Gobi are considered geological deserts because they are barren wastes of sand. In contrast the North American deserts possess a definite fauna and flora, peculiar to each type, and are in reality biological deserts. The North American deserts each possess a definite rainfall period varying from five to 10 inches in the various deserts. As the rains are irregular and indefinite, drouths of long and short periods are characteristic. The open stand of vegetation and the exposed and barren desert floor coupled with low humidity and high temperatures produce excessive evaporation. Usually during a normal rainy season sufficient moisture falls on any particular desert to send the vegetation bursting into full bloom in a surprisingly short period of time. For instance Ocotillo (*Fouquieria splendens*) comes forth fully leaved within two days of a good shower breaking a drouth of many months duration. Frost is practically unknown in certain deserts, such as the Sonoran Desert, and the distribution of many plants, such as *Olneya tesota* and *Atriplex hymenolytra* are strictly limited to the frost-free areas of the desert. Water courses are very rare and even large streams coming out of the nearby high mountains are soon licked up by the avid air or disappear beneath the sands to occasionally reappear where rock ledges force the underground water to the surface again.

The plant life is characterized by succulents and microphyllous xerophytes. Succulents include many genera of cacti such as: *Opuntia Mammalaria, Ferocactus, Echinocereus, Peniocereus, Coryphantha* and *Asterophyton* and many others. Giant cacti such as the Sahuaro, *Gigantocereus,* Organ Pipe *Lemaireocereus,* and *Pachycereus* add a strong forest-like vista to certain desert types. Microphyllous xerophytes include numerous genera such as: Creosote Bush *Larrea,* Ocotillo *Fouquieria,* Palo Verde *Parkinsonia* and *Cercidium,* Mesquite *Prosopis,* Acacias, Mimosas, Condalias, Lyciums and many others. Plants with long stemmy thorns include *Koeberlinia, Canotia* and *Holocantha.* Flowering plants are found growing along the water courses where the arroyos rush by during the storms, in clumps of desert shrubs, and in crevices and the protection of rocks; of these Composites predominate. Xeric ferns such as *Notholaena, Cheilanthes, Pellaea* and other genera are found growing in the crevices of rocks in the desert mountains. The Resurrection plant, *Selaginella* is a common member of the desert hillside flora.

Out of this vast assemblage of desert plants one in particular more accurately delineates the extent of the deserts of North America by its distribution than any other plant and that is the Creosote bush, *Larrea divaricata.* The periphery of its extensive dispersal is taken to be that of the Sonoran and Chihuahuan Deserts. The Great Basin Desert is delimited by the Sagebrush *Artemisia tridentata.* Another desert plant, Ocotillo, has much the

same range as the Creosote bush. Although the Creosote bush outlines the extent of the desert it is not sufficient to characterize the flora of the North American Deserts for associated with it are many other plants, shrubs and trees characterizing each of the desert types.

Floristic Composition and Distribution of the North American Desert

North America possesses four main deserts namely, the Sonoran, Chihuahuan, Great Basin and Lower Californian desert. Each possesses a distinctive fauna and flora. The Sonoran and Chihuahuan deserts are divisible into certain subtypes.

THE CHIHUAHUAN DESERT

The Chihuahuan Desert is the Eastern Desert tract of southwestern Texas and northeastern Mexico. This desert occupies the Rio Grande Valley from the Pecos River westward sending long arms up the Pecos River to the Carlsbad vicinity in New Mexico; up the Otero Basin to Alamagordo and the Rio Grande valley in New Mexico north as far as Albuquerque. Chihuahuan vegetation also extends into the southeastern corner of Arizona. In Mexico the Chihuahuan desert occupies the eastern half of the State of Chihuahua and northern Durango and Coahuila east to the western edge of the Sierra Madres Oriental. In the Saltillo-Monterrey section the desert breaks through a pass to within fifteen miles of Monterrey at the east base of the Sierra Madres Oriental. In southern Coahuila several high sierras of limestone rock extend from the Sierra de Parras east to Carneros Pass, just south of Saltillo, and more or less isolate the Chihuahuan desert from the higher Creosote valleys to the south of these sierras. This area has been called the Valle de Salado. It is largely unexplored; one of the first expeditions to this region was made by Dr. Forrest Shreve and the writer in August and September of 1940. Present indications tend to show that this region with its interesting fauna and flora may ultimately be considered a subtype of the Chihuahuan Desert. It is here called the Desert of Salado and two new Decticids will be described from that desert.

Dominant plants of the Chihuahuan Desert are: *Larrea divaricata, Agave lechuguilla, Flourensia cernua, Prosopis chilensis, Fouquieria splendens, Dasylirion texanum, Koeberlinia spinosa, Sericodes greggi, Acacia greggi, farnesiana, paucispinosus, vernicosa, Jatropha spathulata, Berberis trifoliata, Condalia lyciodes, Lippia lyciodes, Opuntia lindheimeri* and other spp., *Mammalaria* spp., *Echinocereus stramineus, conglomeratus, Ferocactus ingens, F. longihamatus, Yucca macrocarpa, Y. treculiana, Candelaria antisiphiliticus, Coldenia greggi, C. canescens* and many other typical plants.

The principal plants of the Solado Desert includes such species as: *Larrea divaricata, Hectia* sp., *Lycium leiospermum, Agave lechuguilla, Ephredra antisyphiliticus, Mortonia hidalgensis, Symphora secundiflora, Cassia wislizeni, Prosopis* spp., *Dasylirion longissima, Opuntia tunicata, Ferocactus pringlei, Yucca carnerosana,* and a great variety of other cacti and plants.

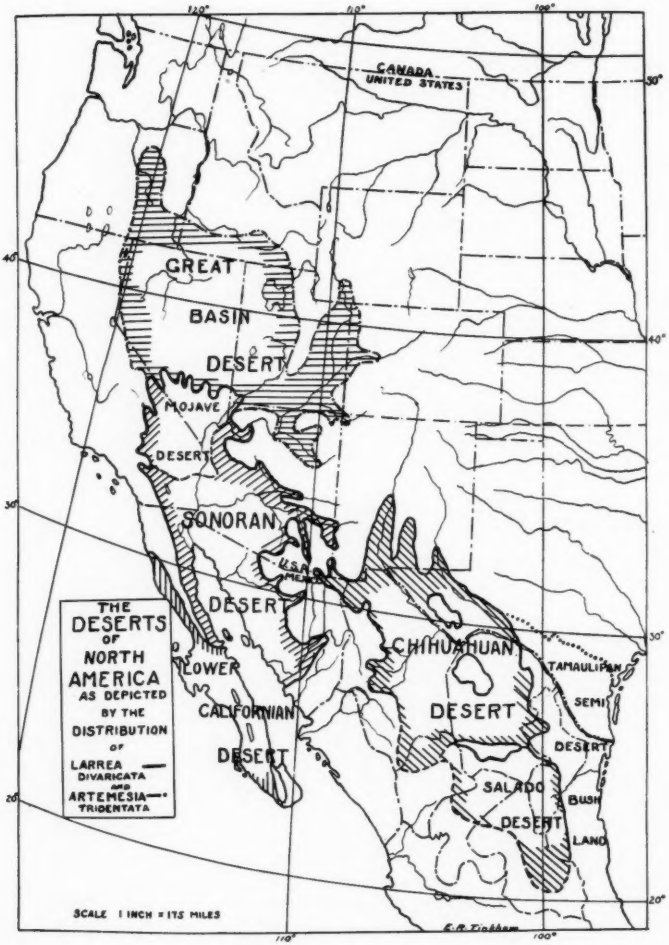


Fig. 1. Map defining the extent of the deserts of North America.

TAMAULIPAN SEMI-DESERT BUSHLAND

The coastal plains east of the Sierra Madres Oriental and the eastern slopes of this steep range of mountains are dominated by a semi-tropical vegetation that becomes taller and denser as one proceeds south of Laredo. At Salinas Hidalgo the height of this vegetation is less than ten feet, at Monterrey over ten feet in height and at Cuidad Victoria the height of this bushland would average twenty feet. This vegetation is here called the Tamaulipan Semi-Desert Bushland. It extends from the southern edge of the Edwards Plateau, just north of Uvalde, Texas, south to Tampico and from the Pecos River and the Sierra Madres Oriental east to the Gulf of Mexico. In the Laredo region the common plants are: *Acacia berlandieri, A. roemeriana, A. wrighti, Prosopis glandulosa, Opuntia lindheimeri, Circidium macrum, Porliera angustifolia, Leucophyllum misum* and other plant species. As one progresses south other dominants appear. At the Rio Salado *Cordia boussieri* and *Karwinskia humboltiana* appear and soon, if it is late August, the sweet yellow catkins of *Pithecolobium brevifolium* scent the air and stretch like a sea of yellow before one's eyes. Other species such as *Agave americana, Yucca australis* with its pendant fruiting masses, *Gochnatia hypoleuca, Mimosa pigra* add new interest to the flora. Just north of Cuidad Victoria at the Rio Santa Garcia, the tall organ-pipe-like giant cactus *Myrtilocactus geometrizans* grows in the tall bushland which now averages twenty feet in height. South of Cuidad Victoria this Bushland merges with the tropical forests found at Tamazunchale.

THE SONORAN DESERT

The Sonoran Desert occupies all of southern Arizona south of the Mogollon Rim following up the Gila River to the eastern edge of Arizona, up the San Pedro to Naco where it meets an influx of Chihuahuan plants such as *Acacia vernicosa, Flourensia cernua,* and *Forestieria angustifolia,* and the Santa Cruz and Altar Valleys but does not reach the Mexican boundary. West of the Baboquivari mountains the desert extends south to the Yaqui river where it merges with the Sinaloan Thorn Forest. The northern limits of the Sonoran Desert are the extreme southwestern corner of Utah and southern Nevada where long tongues of Creosote extend up the valley floors between the numerous mountain ranges. Creosote is found in Death Valley and on the slopes of the barren mountains of the neighborhood such as the Funeral, Panamint and Inyo mountain ranges. The outposts of *Larrea* extend to five miles north of Olancha in Owens Valley at the east base of the Sierra Nevadas. The western limits of the Sonoran Desert are the Tehachapi, San Gabriel, San Bernardino, Santa Rosa and the Laguna mountains of California, and the Sierra del Capirote and San Pedro Martia mountains of Baja California. The southern limits are approximately opposite Tiburon Island according to the authority, Dr. Forrest Shreve.

Subdivisions of the Sonoran Desert include the well known Mojave Desert lying north and east of the San Bernardino Mountains north to the limits of *Larrea* and east to the Colorado River and crossing into Arizona north of the Williams River.

The extreme desert of Imperial valley lying south of the San Bernardinos and north of the Gulf of California and east of the Santa Rosa, Laguna and Capirote mountains to the Colorado has often been called the Colorado Desert but this subdivision is somewhat debatable.

The dominant plants of the Sonoran Desert include: *Larrea divaricata, Prosopis velutina, P. juliaflora, Cercidium torreyanum, Olneya tesota, Acacia constricta, Opuntia fulgida, O. versicolor, O. engelmanni, O. arbuscula, O. acanthocarpa, Dondia menzeii, Krameria spinosa, Franseria deltoides* and other plants. On the south slopes of the mountains the Sahuaro-Palo Verde-Encelia Zone is found characterized by such plants as the Sahuaro *Gigantocereus carnegei,* Palo Verde *Parkinsonia microphylla* and *Cercidium aculeata, Encelia farinosa, Opuntia bigelovii, Jatropha cardiophylla, Fouquieria splendens, Coursettia glandulosa, Acacia dysocarpa, Erythrina flabelliformis, Lemaireocereus thurberi* the Organ-Pipe Cactus and other interesting plants.

The principal plants of the Colorado Desert include such species as *Larrea divaricata, Franseria dumosa, Coldenia palmeri, Parosela spinosa, Cercidium floridum, Eriogonum deflexum, Petalonyx thurberi, Agave deserti, Washingtonia filifera* a Palm, *Oenothera deltoides, Eriogonum inflatum, Opuntia bigelovii* and many others.,

MOJAVE DESERT

The Mojave Desert has an interesting flora, the following being characteristic of that desert: *Yucca brevifolia* the Joshua Tree, *Y. mojavensis, Y. baccata, Larrea divaricata, Franseria dumosa, Holocantha emoryi, Coleogyne ramossisima, Hymenoclea salsola, Atriplex confertifolia, A. canescens, Allenrolfea occidentalis, Canotia holocantha, Opuntia acanthacarpa, O. parishii, ursina, O. mojavensis, Cereus mojavensis, C. engelmanni,* and many other interesting plants.

THE GREAT BASIN DESERT

North of the Sonoran and Mojave Deserts, the Great Basin Desert of Sagebrush is found covering all of northern Nevada, most of Utah except the high mountains, western Colorado, northeastern Arizona and southeastern Oregon and the northeastern corner of California. The dominant plant of this vast desert is *Artemisia tridentata,* the Desert Sagebrush, popularly known as the "Purple Sage" of the novelists. Unlike the Sonoran and Chihuahuan Deserts, the Sagebrush Desert is far less conspicuous and with a more uniform plant coverage of low height. No Yuccas, Ocotillos or mesquites are to be seen adding variety to the desert landscape as they do farther south. Cacti are few and of small size. Junipers are found at higher elevations in the mountains with sagebrush plants nearby.

Characteristic plants of the Great Basin Desert are: *Artemisia tridentata, A. nova, A. spinescens, Atriplex confertifolia, Grayia spinosa, Chrysothamnus nauseosus, C. graveolans, Sarcobatus vermiculatus, Tetradymia spinosa, Coleogyne ramossisima, Kochia vestila, Eurotia lanata, Cowania stansburiana, Hilaria jamesii* and other species.

LOWER CALIFORNIAN DESERT

The southern half of the Californian Peninsula is occupied by a strange desert that is little known at present. It is one of the few areas that the writer does not know from first-hand experience. Its extreme isolation, aridity and in accessibility accounts for its obscurity and strangeness. The plants recorded here are taken from Dr. Forrest Shreve's "A Desert by the Sea." The principal plant is the bizarre and remarkable Citio *Idria columnaris* that with their stout tall trunks and twisted spiny limbs resemble a burnt-over pine forest. Other characteristic plants are: terote, *Pachycormus discolor, Yucca valida* the Giant Yucca, *Agave goldmaniana, Pachycereus pringlei* the Giant Cactus, Ocotillo *Fouquieria peninsularis,* and the creeping devil *Machaerocereus eruca.* Areas along the Pacific coast in this desert despite the lack of rain have high and incessant winds ladened with moisture. Not until road conditions are bettered can it be expected that this strange desert will be more frequently studied.

Zoogeography of the Decticinae

The North American Deserts possess a rich and varied Orthopteran fauna. The Band-winged Grasshoppers of the subfamily Oedipodinae predominate with the Cyrtacanthacrinae and Acridinae close seconds. The Katydids of the family Tettigoniidae are fewer in number and of these the Shield-back Katydids of the subfamily Decticinae are the richest in species, strangest in form and rarest in collections.

Twenty-seven genera of Nearctic Decticinae are to be found in Mexico, United States and Canada, comprising a total of ninety-one species. Of this assemblage several are boreal in habits and distribution, others are campestrian or dwelling on the Great Plains, some monticolous or dwelling in mountains, but the great majority are eremiophilous or inhabitants of the great North American Deserts. To California belongs the honor of having the richest Decticid fauna in North America with some thirteen genera and thirty-nine species known to date. Perhaps no other region of the world possesses a more interesting and varied fauna than this state. The zoocenter of distribution of the Nearctic Decticids appears to be Owens Valley at the east base of the Sierra Nevadas where no less than nine genera and fifteen species have been found.

Of the Neogeic genera, one species *Metrioptera sphnagnorum,* closely allied to Siberian species, is found in northern Canada. *Metrioptera* is unquestionably a Gerontogeic genus with some sixty known species on the Eurasian continent. *Atlanticus* is an even more interesting genus with nine North American species known from the Eastern United States between the Mississippi River and the Atlantic seaboard and from Maine to Florida. Ten species are known from eastern China and Siberia, of which seven have been newly described by the writer.* *Pediodectes* is largely a Great Plains genus as is also

* Zoogeographical Notes on the Genus *Atlanticus* with Keys and Descriptions of Seven new Chinese Species. Notes d'Entomologie Chinoise, Shanghai, fall of 1940. Not yet received.

Anabrus simplex, the Mormon Cricket. *Hubbellia* is known only from Florida. *Anabrus, Peranabrus, Steiroxys,* and *Apote* are northwestern genera largely confined to Washington, Idaho and British Columbia. *Idionotus* and *Clinopleura* and *Decticita* are restricted to the western side of the Sierra Nevadas of California. The rare *Acrodectes philopagus* is found feeding on rock lichens at Arctic temperatures at elevations of 12,000 to 13,000 feet above timberline on the slopes of Mt. Whitney, the highest peak in the United States. *Neobarrettia* and *"Stipator"* are Mexican genera. The remaining genera, 15 in number, to be discussed in the following pages, are found on the North American Deserts.

Host Plant Relationships

The Shield-back Katydids of the various deserts naturally find their host plants in some of the dominant plants of the desert. It is interesting that such a plant as the Creosote bush despite its sticky pungent leaves should have eighteen species of Orthoptera feeding on it in the Chihuahuan and Sonoran Deserts. Of this number five are grasshoppers, two crickets, three katydids and six are Shield-backs. The Sagebrush also has a large associated fauna of decticids. Mesquites and Acacias are also favored for the protection they give and even pines have some species.

A summary is here given of the Desert Decticids according to their host plant. The Creosote bush has the following Chihuahuan decticids: *Rehnia cerberus, Eremopedes scudderi* and *Eremopedes covilleae* while the Sonoran Desert claims *Eremopedes bilineatus, Ateloplus splendidus* and *Anoplodusa arizonensis*. Species peculiar to the Sagebrush *Artemisia tridentata* are: *Idiostatus inyo, I. inermis, I. elegans, I. nevadensis, I. magnificus, I. variegatus, I. hendersoni, Neduba carinata, Aglaothorax segnis* and *Ateloplus hesperus*. In Mesquite are found *Capnobotes fuliginosus, Rehnia cerberus, R. victoria, R. n. sp.* and *Eremopedes* n. sp. *Acacia* is favored with the following species: *Rehnia cerberus, R. victoria, Eremopedes scudderi, E. ephippiatus, Ateloplus schwartzi* and *Capnobotes fuliginosus*. Hiding in the sharp-pointed leaves of Yucca are found *Aglaothorax armiger, A. segnis, Neduba castanea, Ateloplus minor, Eremopedes ephippiatus* and *E. scudderi* and *Pediodectes* sp. Junipers possess such species as *Pediodectes bruneri, Capnobotes occidentalis* and *Aglaothorax armiger*. In Pines the following have been taken: *Capnobotes bruneri, Neduba carinata, N. sierranus, Aglaothorax ovatus, A. segnis*. Two species have been taken in Oaks namely: *Aglaothorax ovatus* and *Neduba diabolicus*. In *Atriplex confertifolia* have been taken *Zycloptera atripennis, Ateloplus luteus* and *Capnobotes fuliginosus*.

Economic Status

Of all the North American Decticid genera only *Anabrus* and *Peranabrus* assume an economic role. *Anabrus simplex*, popularly known as the "Mormon Cricket," has a long notorious history since it first devastated the early Mormon colonies in Utah. Since that time few years pass without some outbreak somewhere in its territory of Montana, Utah, Idaho or Wyoming. The years 1938 and 1939 saw heavy infestations in northeastern Wyoming and

Idaho. Another species *Anabrus longipes* occasionally becomes injurious in British Columbia and Washington. The Coulee Cricket *Peranabrus scabricollis* is also a very injurious species especially in the state of Washington. Of the remaining eighty-eight species none is injurious and a large portion of these is to be considered rarities in any collection.

Collection and Preservation

As practically all the Shield-Back Katydids are nocturnal, the best method of collecting them is to do night collecting by flashlight following the songs of the males. This is a long, tedious but interesting task and brings results. Another method is to sweep desert plants wherever practical, and still another way is to tramp through bushes scaring out the katydid inhabitants. This is especially workable with sagebrush and similar plants and many rare forms are obtained in this fashion.

As the colors of Decticids are rather delicate and often very beautiful, and their body cavities filled with fluids, every specimen should be gutted and lightly stuffed with cotton if a worth-while collection is desired. Otherwise the specimens will black and many decay before drying. An incision is made at the base of the abdomen, three segments long, and the alimentary tract, seminal vesicles in the males and ovaries in the females, removed with forceps. If the body contains much fluid it should be very lightly swabbed out with absorbent cotton. Then a small roll of cotton is made, the same size as the alimentary tract, and pushed forward into the thorax-end of the creature. The abdomen is fluffed out and the roll of cotton worked back into the abdomen; sometimes it is necessary to add a little cotton for the thorax. In this manner the natural size of the katydid is retained and the beautiful life colors preserved. The sooner this procedure is accomplished after death of the katydid, the better the results.

In the following pages, generic key and specific keys to the various genera will be given. Whatever is known about the Biology, Habits, Song and Host Plants will be given under each species. This material is based almost entirely upon the writer's own study and observation based on many years' work in the field. Two new species and two new subspecies will be described.

KEY TO THE GENERA OF NORTH AMERICAN DESERT DECTIDES

1. Tegmina and wings very long, exceeding the tip of the abdomen 2
   Tegmina and wings not reaching the apex of the abdomen 3
2. Size large to very large with greyish or greenish tegmina; ovipositor decurved ..... *Capnobotes*
   Size medium, tegmina greenish buff spotted with round ivory white dots; ovipositor decurved ..... *Anoplodusa*
3. Tegmina longer than the pronotum 4
   Tegmina shorter than the pronotum 6
4. Size large, color greenish or grayish 5
   Size small, mottled green; tegmina right-angled triangular, reddish. Pronotum with caudal margin slightly concave and decidedly reflexed. Caudal femora black at base and red at the apex; caudal tibiae reddish; cerci very large, straight, with large, stout, median uncinate tooth ..... *Acrodectes*

5. Pronotum subsellate, the posterior margin strongly raised and marked with nacreous. Femora with large or small spine rows. Wings pale green with irregular bands or spots of black and sometimes margined with yellow. Sternites toothed; color foliage green; ovipositor long and decurved ..... *Rehnia*

Pronotum flat, color light to dark stone gray mottled with cream; tegmina bister mottled with creamy spots. Femora with only a few small spines. Wings shining jet black. Mesosternum only spined. Ovipositor long and decurved ..... *Zycloptera*

6. Pronotum very large and shield like, circular in outline and completely hiding the male tegmina; posterior margin circularly rounded and lateral keels very strong and convex 7

Pronotum small, not circular in outline, with the male tegmina exposed; posterior margin usually squarely truncate, rarely slightly rounded; keels if present parallel or subparallel 8

7. Pronotum with disk very large, oval in outline, the constriction one tenth the pronotal length caudad of the anterior margin. Margins and disk of pronotum heavily etched with black. Pseudo-cerci with a minute sub-apical tooth; ovipositor long and recurved ..... *Aglaothorax*

Pronotum smaller, the enlarged portion semi-circular in outline, the constriction one-fifth the pronotal length caudad of the anterior margin. Color mainly brown and disk margin not heavily etched with black. Pseudo-cerci without an inner subapical tooth in the large species; ovipositor long and recurved .... *Neduba*

8. Pronotum with lateral keels 9

Pronotum without trace of lateral keels 10

9. Pronotum with parallel lateral margins, disk flat with a depression on the metazona. Ovipositor long and decurved ..... *Plagiostira*

Pronotum with lateral keels constricted in the anterior third, median carina faint. Ovipositor long and gently recurved; pronotum flat ..... *Idionotus*

10. Pronotum almost square, of uniform breadth throughout, the lateral lobes shallow and broadly rounding into the disk of the pronotum; posterior margin squarely truncate. Size large to small ..... *Ateloplus*

Pronotum more elongate, lateral lobes deeper and more angularly rounding into the disk of the pronotum. Size small to large 11

11. Posterior margin of pronotum convexly rounded; prosternal spines always present. Size medium to large ..... *Pediodectes*

Posterior margin squarely truncate; prosternum usually unarmed. Size small to medium 12

12. Exposed tegmina less than one-half the length of the pronotum. Metazona of the pronotum smoothly rounded into the lateral lobes and with disk very slightly reflexed ..... *Eremopedes*

Exposed tegmina more than one-half the length of the pronotum. Metazona of the pronotum angularly rounded into the lateral lobes and with the disk slightly reflexed and bearing a trace of a median carina..... *Idiostatus*

CAPNOBOTES Scudder

1897. *Capnobotes* Scudder. Can. Ent., **29**:73-74.

1897. *Capnobotes* Scudder. Guide N. Amer. Orth., p. 55.

1900. *Capnobotes* Scudder. Cat. Orth. U. S., p. 76.

1904. *Capnobotes* Cockerell. The Ent., **37**:178-181.

1906. *Capnobotes* Kirby. Syn. Cat. Orth., p. 181.

1907. *Capnobotes* Caudell. Proc. U. S. Nat. Mus., **32**:310-311 (Key).

1934. *Capnobotes* Caudell. Pan-Pac. Ent., **10**(4):151-152 (Key).

This large and handsome genus is characterized by its large to very large size, fully caudate tegmina and wings and mottled greyish or greenish coloration. The pronotum is rather narrow, subsellate, laterally constricted in the center and with the disk of the metazona flat and gently tilted upwards and backwards. The posterior margin is convexly rounded. The tegmina and wings are long approximately twice the length of the body. Male supra-anal plate is triangular with the apex often elongated; the entire plate cut by a narrow incision. Ovipositor as long or shorter than the caudal femora and gently decurved. Femora of all legs with small teeth. Fore and middle tibiae with long ventral and shorter dorsal teeth; caudal tibiae with short dorsal and strongly appressed ventral teeth. Prosternites with a pair of spined lobes; meso- and metasternites with triangular plates.

Genotype.—Locusta fuliginosa Thomas.

The species of *Capnobotes* are all nocturnal although rarely they are heard to sing by day. Although herbivorous and feeding on the leaves of their host plants, the species are carnivorous and feed voraciously on insects and their own members when in captivity. *Capnobotes* is largely confined to the Sonoran Desert but ranges into the southern edge of the Great Basin Desert and is known from the northern portions of the Chihuahuan Desert.

KEY TO THE SPECIES OF CAPNOBOTES

1. Size very large, mottled gray with black wings and heavy buff antennae; ovipositor strong, gently decurved and distinctly shorter than the caudal femora.....*fuliginosus*
   Size medium, mottled green or gray with hyaline wings and reddish brown antennae; ovipositor gently decurved and as long or longer than the caudal femora 2
2. Color mottled green or gray; tegmina of uniform width throughout its entire length .....*occidentalis*
   Color grayish mottled with brown on the tegmina which are strongly constricted in their apical half .....*bruneri*

CAPNOBOTES FULIGINOSUS (Thomas)

1872. *Locusta fuliginosa* Thomas. Ann. Rept. U. S. Geol. Surv. Terr., **5**:443, pl. 1, fig. 9.
1875. *Locusta fuliginosa* Thomas. Rept. U. S. Geol. Surv. W. 100 Mer., **5**:906.
1884. *Locusta fuliginosa* Riley. Stand. Nat. Hist. **2**:191.
1897. *Capnobotes fuliginosus* Scudder. Can. Ent., **29**:74.
1900. *Capnobotes fuliginosus* Scudder. Cat. Orth. U. S., p. 76.
1903. *Capnobotes fuliginosus* Caudell. Proc. U. S. Nat. Mus., **26**:806.
1904. *Capnobotes fuliginosus* Rehn. Proc. Acad. Nat. Sci. Phila., p. 573.
1904. *Capnobotes fuliginosus* Cockerell. The Ent., **37**:180.
1906. *Capnobotes fuliginosus* Kirby. Syn. Cat. Orth., **2**:181.
1907. *Capnobotes fuliginosus* Caudell. Proc. U. S. Nat. Mus., **32**:311.
1907. *Capnobotes fuliginosus* Rehn. Proc. Acad. Nat. Sci. Phila., p. 64.
1934. *Capnobotes fuliginosus* Caudell. Pan-Pac. Ent.,
1935. *Capnobotes fuliginosus* Hebard. Trans. Amer. Ent. Soc., **61**:310.
1938. *Capnobotes fuliginosus* Tinkham. J. N. Y. Ent. Soc., **46**:349.

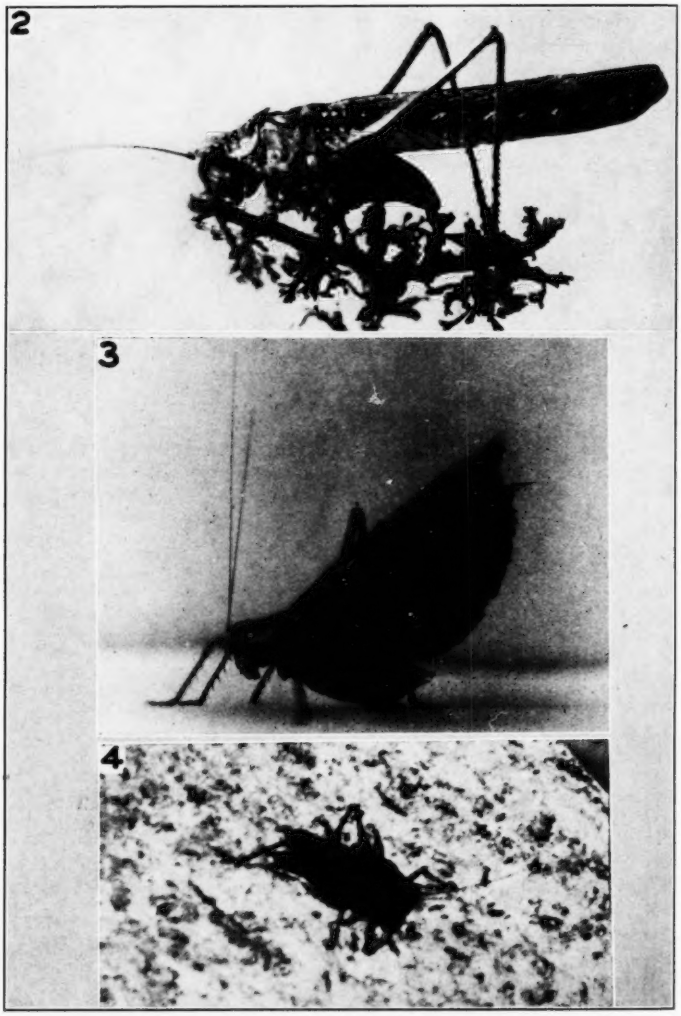


Fig. 2. Male *Capnobotes fuliginosus* perched in the top of a small bush.

Fig. 3. Male *Capnobotes fuliginosus* in fighting attitude with black wings and tegmina raised above its body.

Fig. 4. Male *Acrodectes philopagus* singing on a granite boulder at 12,100 feet on the Whiney Pass, Oct. 22, 1939.

Description.—The chief features characterizing this handsome species have been presented in the key. The cercus of this species is long and narrow with two apical internal hooks.

Biology.—At present nothing is known about these in particular.

The species matures by mid-June and is found in the adult stage until November but it is not known whether it survives through the winter as does *Neoconocephalus triops* one of the Cone-headed Katydids.

Habits.—This handsome species appears to be strictly nocturnal in habits although in the fall with the colder nights appearing, it may sing occasionally in the day time. Usually, however, the singing commences with the crepuscular light of dusk and continues on late into the night. Although phyllophagous to some extent it is believed that *fuliginosus* is predominantly carnivorous as would be attested by the spiny fore legs. When confined this species devours large insects, especially grasshoppers. Such insects are grasped tightly by the fore and middle legs and the strong mandibles with a few swift strokes crush in the head and bases of the legs. Then in a more leisurely fashion the prey is devoured. When irritated or annoyed this species raises its tegmina and black wings over its back and is then ready to fight.

Song.—The song is loud and continuous enduring for a long period of time unless broken by the approach of some enemy. It is almost impossible to approach this species without being detected. The note is difficult to interpret into words as it has a fluttering quality about it and can best be indicated as something like "zik-k-k-k-k-k—zik-k-k-k-k-k—zik-k-k-k-k-k" with the "ks" fluttering and undulating in tone. On October 19, 1939, while in the Chaparral Zone near the mouth of Wheeler Canyon in the Hualapai mountains of northwestern Arizona the writer stopped to investigate a song that sounded much like that of some unknown cicada. It was 1 p. m. on a warm fall day. Imagine the writer's surprise to find two males of *fuliginosus* singing to each other in the dense chaparral. One of the males was finally captured.

Host Plants.—The host plant varies according to the desert habitat. Large bushes or trees are usually chosen. On the desert at the mouth of Madera Canyon in the Santa Rita range mesquite *Prosopis velutina* is the host plant. At the north end of the Quinlan range which are the continuation of the Baboquivaris the writer took a large series in Palo Verde *Cercidium aculeatum.* At Walkers Lake, Nevada, a male was taken in *Atriplex confertifolia,* and in the Hualapai mountains the host plant was chaparral. On other occasions the host plant has been some species of *Acacia.*

Records.—Texas: Paisano, Presidio Co. July 23, 1929, 1 ♂; Mulligan Canyon near El Paso, Sept. 18, 1931, 6 ♂; North end of Davis Mts., 6 miles SW. Toyahvale, Sept. 13, 1940, 1 ♂ (all E. R. Tinkham).

New Mexico: Animas Mts., Sept. 18, 1937, 1 ♀ (L. N. Gooding; U. of Ariz. Cln.).

Arizona: Huachucas reported by Rehn in 1907, Madera Canyon, Santa Ritas, Sept. 1-2, 1938, 6 ♂ (E. R. Tinkham). Cienaga Wash, 30 miles E. Tucson, June 16, 1940, 1 ♂; Quinlan Mts., Sept. 3, 1931, 10 ♂, 2 ♀ (E. R. Tinkham; Hebard Cln.). Hualapai Mts., Oct. 19, 1939, 1 ♂ (E. R. Tinkham). Kofa Mts., May 18, 1937,

1 ♂ (L. N. Gooding). Utah: Beaver Dam mountain pass just west of St. George, July 28, 1930 (E. R. Tinkham; Hebard Cln.). Nevada: Virginia City, July 28-31, 1931, 6 ♂ (E. R. Tinkham; Hebard Cln.). Walkers Lake, Aug. 14, 1938, 1 ♂ (E. R. Tinkham). Calif.: South end Lake Tahoe, Aug. 11, 1930, 1 ♀ (E. R. Tinkham; Hebard Cln.).

Distribution.—*Capnobotes fuliginosus* is a member of the lower Sonoran Fauna occupying in distribution the Sonoran Desert and southern portions of the Great Basin Desert. It is also known from the northern part of the Chihuahuan Desert but as yet is unknown from any part of Mexico although certainly occurring there.

CAPNOBOTES OCCIDENTALIS (Thomas)

1872. *Locusta occidentalis* Thomas. Ann. Rept. U. S. Geol. Surv. Terr., **5**:444.
1872. *Capnobotes occidentalis* Glover. Ill N. Am. Ent., Orth., pl. 9, fig. 16.
1897. *Capnobotes occidentalis* Scudder. Can. Ent., **29**:74.
1900. *Capnobotes occidentalis* Scudder. Cat. Orth. U. S., p. 76.
1902. *Capnobotes occidentalis* Woodworth. Bull. No. 142, Calif. Exp. Sta., p. 15.
1904. *Capnobotes occidentalis* Cockerell. The Ent., **37**:179.
1906. *Capnobotes occidentalis* Kirby. Syn. Cat. Orth., **2**:182.
1907. *Capnobotes occidentalis* Caudell. Proc. U. S. Nat. Mus., **32**:315.
1934. *Capnobotes occidentalis* Caudell. Pan-Pac. Ent., **10**(4):152.
1935. *Capnobotes occidentalis* Hebard. Trans. Amer. Ent. Soc., **61**:310.
1935. *Capnobotes occidentalis* Hebard. Proc. Acad. Nat. Sci. Phila., p. 74.

Description.—Two phases of this species occur, the green and the grey both of which are mottled with flecks of white especially on the tegmina. The green phase bears the varietal name of *viridis*. This species differs from *C. fuliginosus* by lacking black wings, much smaller size and longer ovipositor in the female. The male cercus is apically armed with a short internal spine with proximally a large subapical internal prong. The supra-anal plate of the male is more equilaterally triangular with a median grove.

Biology.—Nothing is known about this species. The species is adult in June.

Habits.—These are similar to *C. fuliginosus* but more alert.

Song.—A strong zik-zik-zik, continuous but not as fluttering as in *fuliginosus*.

Host Plants.—Junipers were the host of this species 6 miles northwest of Mojave. A few miles west of Big Pines on the road to Glacier Lodge the writer found two females of *occidentalis* in a honey locust tree.

Records.—Three miles west of Big Pine, Aug. 16, 1938, 2 ♀ (E. R. Tinkham). Six miles northwest Mojave, Aug. 8, 1931, 1 ♀ (E. R. Tinkham; Hebard Cln.). Walker Pass, Aug. 22, 1938, 1 ♀ (E. R. Tinkham). These are California records. Littlefield, Arizona, Aug. 29, 1936, 1 ♂ (E. D. Ball; Univ. of Ariz. Cln.). New Mexico records, Hebard 1935.

Distribution.—*Capnobotes occidentalis* is a member of the Lower portions of the Great Basin Desert which would account for its penetration into northwestern New Mexico with Pecos, New Mexico, representing the southeastern limit in the distribution of this species.

CAPNOBOTES BRUNERI Scudder

1897. *Capnobotes bruneri* Scudder. Can. Ent., **29**:74.
1900. *Capnobotes bruneri* Scudder. Cat. Orth. U. S., p. 76.
1902. *Capnobotes bruneri* Woodworth. Bull. No. 142, Exp. Sta. Calif. p. 15.
1904. *Capnobotes bruneri* Cockerell. The Ent., **37**:181.
1906. *Capnobotes bruneri* Kirby. Syn. Cat. Orth., **2**:181.
1907. *Capnobotes bruneri* Caudell. Proc. U. S. Nat. Mus., **32**:317.
1934. *Capnobotes bruneri* Caudell. Pan-Pan. Ent., **10**:151, fig. 2.

Description.—This species is immediately recognized by abrupt narrowing of the apical half of the tegmina. The coloration is mottled grayish with much rust brown along the central portions of the tegmina. The ovipositor is gently decurved and slightly longer than the posterior femora. *C. bruneri,* based on the length of the ovipositor and the supra-anal plate, would appear to be more closely related to *C. occidentalis* than to the larger *C. fuliginosus.*

Habits.—On August 6, 1931, the writer and his brother Herb, were camped in Paradise Valley in the Pine Zone of the Tehachapi mountains immediately south of the town of Tehachapi. The evening meal had just been finished and darkness was fast approaching when some strong "tzwks" sounded from the tops of nearby towering Western Yellow Pines. As the song was new to the writer, it was decided to make the ascent despite the setting and the arduous task facing the would-be hunter. A flashlight and cyanide jar were slipped into a haversack and thrown over his back. The pine was about four feet in diameter and thirty feet up to the first limbs. My brother held a lighted Coleman lantern to aid my ascent. About fifty feet up the katydid, singing in the top of the pine, heard the hunter and stopped singing, whereupon the hunter sat on a limb for a quarter of an hour for the song to recommence. Finally it was resumed and this time the hunter worked upwards through the limbs with as much cat-like stealthiness as possible. Suddenly, when the song seemed to be immediately overhead, it stopped. The writer reached for his flashlight and turned it cautiously and slowly on what he thought was the spot. There in a clump of long pine needles perched the troubador. The hunter raised himself up another foot with slow and cautious precision. The night was pitch dark and there was no trace of the lantern seventy-five feet below. The pine top was gently swaying as the hunter wrapped his legs around the slender trunk for support. Then with the flashlight in his left hand, the hunter made a sudden grab at the Katydid. As he extricated the katydid from the pine needle the creature responded with a vicious bite that caused an "ouch" to resound through the tree-tops, and as the katydid chewed away on finger tissue the flashlight was replaced and the cyanide jar obtained and the lid unscrewed with the fingers of one hand holding it. Finally the katydid was ensconced within the jar and trembling with the strain and excitement, a feeling of great relief came when two hands again gripped the tree. Elated, the hunter worked his way down through a maze of limbs to the ground. The specimen proved to be the first male ever taken of *Capnobotes bruneri* and today rests in the Hebard Collection at the Academy of Natural Sciences of Philadelphia.

Song.—The song is a strong continuous "tzwik-tzwik-tzwik" interpolated by a brief pause of several seconds between the "tzwiks."

Biology.—Nothing is known about the biology of this wary creature.

Host Plants.—The Tehachapi male was taken in *Pinus ponderosa,* the Western Yellow Pine and this is the only host record.

Records.—The type locality for the female type was Tepusquet Peak, in Santa Barbara County, California. Caudell, in 1934, records the second known female from Davis, California. The only known male was taken in the Pine Zone in Paradise Valley of the Tehachapi mountains, August 6, 1931, 1 ♂, (E. R. Tinkham; Hebard Cln.).

Distribution.—The range as understood at present is represented by the Tehachapi Mts., Tepusquet Peak, and Davis, California. The species appear to be a member of the Upper Sonoran Fauna occurring in the Pine Zone west of the Sierra Nevada range.

ANOPLODUSA Caudell

1907. *Anoplodusa* Caudell. Proc. U. S. Nat. Mus., **32**:318.

Anoplodusa and *Capnobotes* are the only two Nearctic genera of the Decticinae with fully caudate wings. The size is medium about that of *Capnobotes bruneri* or a medium-sized *C. occidentalis. Anoplodusa* differs from *Capnobotes* by lacking a pair of spines on the prosternum and the ventral surface of the caudal femora. The ovipositor is slightly shorter than the caudal femora and is gently decurved as in *Capnobotes.* The coloration is greenish or buffish with ivory white markings on the pronotum and the tegmina.

ANOPLODUSA ARIZONENSIS (Rehn)

1904. *Drymadusa arizonensis* Rehn. Proc. Acad. Nat. Sci. Phila., p. 573.
1906. *Drymadusa arizonensis* Kirby. Syn. Cat. Orth., **2**:180.
1907. *Anoplodusa arizonensis* Caudell. Proc. U. S. Nat. Mus., **32**:318, fig. 25.
1919. *Anoplodusa arizonensis* Rehn and Hebard. Proc. Acad. Nat. Sci. Phila., p. 479 (♀ described).
1935. *Anoplodusa arizonensis* Hebard. Trans. Amer. Ent. Soc., **61**:310.
1938. *Anoplodusa arizonensis* Tinkham. Journ. N. Y. Ent. Soc., **46**:349.
1942. *Anoplodusa arizonensis* Tinkham. Bull. Chicago Acad. Sci., **6**(12):221-227, 2 figs.

Coloration.—The sexes of this striking and very beautiful creature are closely similar. The tegmina and wings are fully developed, as in *Capnobotes,* and are deep viridian with three rows of large circular spots with tinges of reddish brown on the stridulating field of the male tegmen. The antennae are reddish brown. The head, thorax, and abdomen are pale greenish white with ivory on the labrum, prozona, two small spots on the mesozona and on the posterior half of the metazona. Nacreous spots also mark the mesepisternum, metepimeron and the dorsal basal third of the caudal femora. The metepimeron, humeral angles of the pronotum and the occiput are tinged with reddish brown.

Adaptive Coloration.—This handsome decticid as well as a certain katydid *Insara covilleae* and the grasshoppers *Bootettix argentatus* and *B. punctatus* associated only with the Creosote bush have strangely evolved, along parallel lines of development, a closely similar color pattern for protection. In these the foliage green of the body would appear to represent shadows under the leaves and the ivory spots on the tegmina and the nacreous markings on the body, simulating the sun glistening on the sticky leaves of the Creosote bush, serves to break up the body color into light and shadow; thus presenting a picture of perfect camouflage.

Biology.—The adults are mature by mid-May and live through the hot summer until late July or early August when the ova are laid. The maximum number of ova appears to be a complement of 21 ova for each ovary or a total of 42 eggs, although two different females had only 22 and 28 ova, respectively. The ova measure 5.5-5.6 x 1.6-1.7 mms. and like most Decticid ova are lustrous pale violet gray. At the anterior pole a row of large pits, the micropylar area, is observed under high magnification. The hexagonal cells are arranged in groups or rosettes with a pit in the center of each cell. It is believed that the eggs hatch in the fall during the rainy season and the developing nymphs, after passing the winter, are mature in early May. However, the nymphs of this rare creature remain to be discovered.

Habits.—This rare creature is nocturnal and thamnophilous, dwelling only in the Creosote bush. Its diet is probably strictly herbivorous on the sticky pungent leaves of the Creosote, but in captivity they will feed on grasshoppers. The flight of *Anoplodusa* is swift and low like that of *Schistocerca.*

Song. -- The song is a soft continuous "tsz-e-e-e-ek — tsz-e-e-e-ek — tsz-e-e-e-ek," with each "tsz-e-e-e-ek" rather fluttering. It is quite similar to the song of *Capnobotes fuliginosus,* but much softer and if there should be *Capnobotes* singing in any particular area their songs must be silenced before those of *Anoplodusa* can be heard, if they should be present. The singing commences shortly after sundown and continues at least until midnight and perhaps later.

Host Plant.—The only known host plant of this unusual creature is the Creosote bush.

Records.—The type male was described by Rehn, in 1904, from a single male taken near Florence, Arizona, by Mr. C. R. Beiderman. The female type, described in 1909, came from the foot of the Bird Spring Mountains of extreme southwestern Nevada. Dr. and Mrs. Howard K. Gloyd rediscovered the species in 1941 when the following specimens were taken near Florence: 1 ♂, June 12; 1 ♂, 1 ♀, June 13; 1 ♂, June 15; 1 ♂, July 3; 12 ♂, 1 ♀, July 7-8, 1941, along highway at night. On July 6, the writer captured a pair that had just mated in a creosote bush, at midnight a few miles north of Florence. On July 20, 1941, 9 ♂, 4 ♀ were taken by the author in night collecting in creosote bushes near Florence. Additional records, the first outside of the type locality, in Arizona were made in the spring of 1942 by the writer and are as follows: Maricopa County, 3 to 3.5 miles south of south

end of Sierra Estrellas, 3 ♂, 2 ♀, May 22; Vekol Wash, 1 ♂, May 29; 1 mile east of Vekol Wash on creosote desert, 1 ♂, May 29, 1942 (E. R. Tinkham).

Two additional males are known, one taken by Mr. M. J. Oosthuizen on the Mojave Desert near Mojave, California, June 28, 1932 (Univ. of Minn. Cln.), and the other a pinned male in poor condition collected by Mr. Guy Beevor at Yermo, California, located by the writer and in the Hebard Collection in Philadelphia.

Distribution.—Anoplodusa arizonensis is a member of the Lower Sonoran Fauna, its range extending from the Mojave desert on the west to Florence, Arizona, on the east. The 1942 records indicate a wider distribution than formerly but apparently localized to the creosote covered mesas of the desert.

ACRODECTES Hebard

1920. *Acrodectes* Hebard. Trans. Amer. Ent. Soc., **46**:50.

This genus is peculiar in that the tegmina are right-angled triangularly produced by the obliquely truncate inner apical portions of the tegmina. The posterior margin of the pronotum appears to slightly concave due to strong upward reflection of the posterior portion of the disk of the metazona. The cerci are very long, heavy, straight, with bluntly rounded apex and with a long median uncinate hook on the inner margin; the hook itself bearing fine serrate teeth on its inner margin. All femora unspined. Fore tibiae with six stout pairs of large ventral spines and three similar widely-spaced dorsal spines beyond the basal tympanum. Meso-tibiae with six pairs of ventral and two outer and four inner dorsal spines. Caudal femora short, not reaching to the apex of the abdomen and strongly swollen in the basal half. Caudal tibiae with 14-15 external large and small teeth and 13-16 internal teeth on the dorsal surface, and with five pairs of ventral teeth. Greatest breadth below the eyes and greater than the occipital-clypeal depth. Supra-anal plate broad and narrow with the posterior margin straight and bearing a deep median grove.

Genotype.—Acrodectes philopagus Hebard.

ACRODECTES PHILOPAGUS Hebard

1920. *Acrodectes philopagus* Hebard. Trans. Amer. ent. Soc., **46**:251, figs.

Coloration.—The markings are very unusual in this strange creature. The body color is a beautiful mottled green with fine flecks of black everywhere on the abdomen. The tegmina are reddish brown. The fore and middle legs are greenish and the caudal femora are black at the base and reddish brown in the basal half, as are also the caudal tibiae.

Habits.—This boreal creature perches on granite rocks on the Whitney Pass at elevations of 12,000 to 13,000 feet far above the last outposts of pines at 11,000 feet altitude. The young appear in mid-summer when the hot summer sun melts the deep snow off of rocky talus slopes. On August 21,

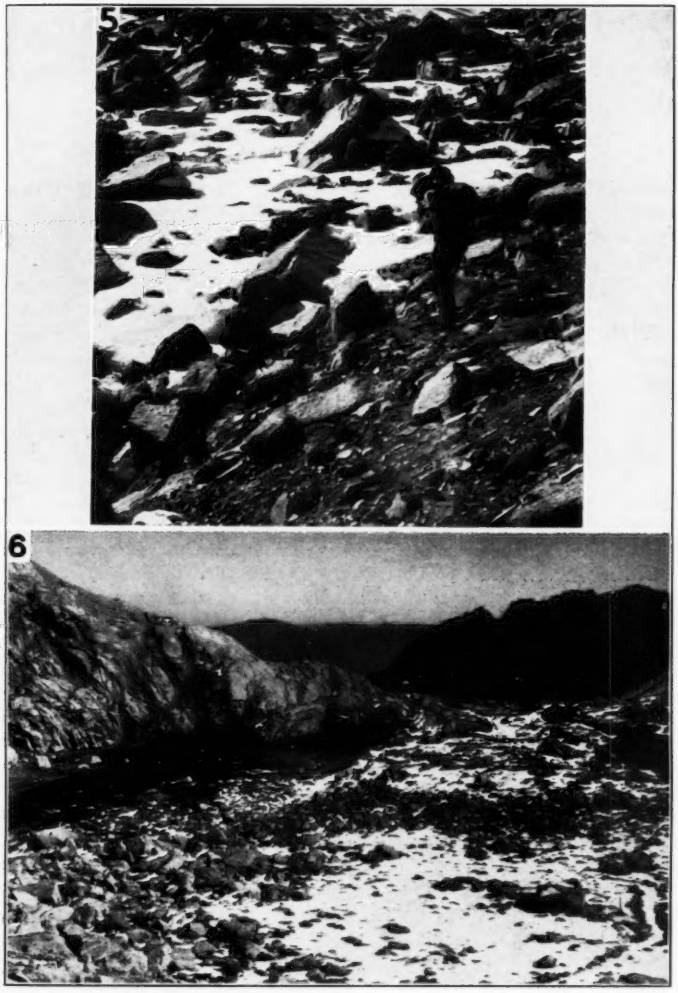


Fig. 5. Habitat of *Acrodectes philopagus* at foot of Whitney Pass, Oct. 22, 1939, showing writer searching for specimens.

Fig. 6. Frozen lake at 12,000 feet at foot of Whitney Pass, Oct. 22, 1939.

1938, the writer and his brother George discovered a small nymph at 12,800 feet on the Whitney pass. It was sitting on top of a small granite boulder on a rocky slide completely surrounded by snow which was still ten feet deep on this day. At that time the writer realized that the adults probably do not appear before late September. Accordingly when an opportunity appeared a year later the writer availed himself of the chance and made an excursion from Tucson, Arizona, to Lone Pine, California, via Death Valley. It was rather late in the fall and snow had already appeared at high elevations in the Sierra Nevadas three weeks earlier. The night was spent at the mouth of Lone Pine Canyon. Breakfast was made the following morning, October 22, 1939, at 5 a.m. and before dawn the writer started off for Whitney Portal in his car. At 6:20 a.m. the writer left Whitney Portal, 7000 feet elevation, on foot. The trail was in the shadow of towering cliffs and the temperature was slightly below freezing. Snow along the trail was frozen solid. Rather lightly clad for the trip the writer was fairly numb with cold long before he made elevations high enough to get into the sun. At 9:30 a.m. the hunter reached 11,500 feet and sunlight. Snow lay everywhere and soon was one foot deep on the level, with bare patches here and there. The writer felt like a fool going up into this world of ice and snow supposedly hoping to find a rare Shield-back Katydid in an arctic world. The air was getting thinner and thinner at this altitude. The hunter left his haversack by a well-marked cliff and proceeded on with camera and net and a bag of sandwiches. At 12,000 feet a small lake was completely frozen over. The base of the Whitney pass was shortly beyond. At 12,100 feet the hunter reached the base which was a south slope and partly bare of snow. The temperature was about 4 degrees Fahrenheit. Leaning up against a rock trying to get his wind the writer thought he heard the familiar "tzick-tzick" of his prize but after an unsuccessful search of the neighboring boulders he thought his subconscious mind had played a trick. Proceeding up the trail, he had gone only a few steps when again the "tzick-tzick" sounded. This time it was real. Looking up the slope the hunter espied his goal on top a small granite boulder some twenty feet above him. What a glorious feeling of triumph and exhilaration surged through him! There on the rock closely pressed against the surface for warmth was a small mottled green katydid with reddish brown tegmina. Its antennae aligned forward were vibrating in the cold breeze. Without disturbing him several photographs were made of this creature in his natural habitat. These photos are shown on the following page.

Song.—The song of this rare creature is a moderately strong "tsick-tsick" audible for a distance of twenty to thirty feet. Each "tsick-tsick" is broken by a pause of several minutes probably due to the low temperatures. At warmer temperatures the pause would probably be shortened.

Food Plants.—*Acrodectes* is pagiophagous, that is, it feeds on the orange and verona brown lichens growing on the granite rocks of the high Sierra Nevadas. At a distance *Acrodectes* looks like a small patch of brown lichen on a granite boulder and thus this curious creature evades its enemies.

Records.—Whitney Pass, 12,800 feet, 1 small ♂ nymph, August 21, 1938 (George Tinkham). Whitney Pass, 12,100 feet, Oct. 22, 1 ♂ 1939 (E. R. Tinkham).

Distribution.—Acrodectes is known only from the rocky talus slopes above timberline in the vicinity of Mt. Whitney, the highest peak in the United States.

REHNIA Caudell

1907. *Rehnia* Caudell. Proc. U. S. Nat. Mus., **32**:305.

Size medium to large, color green with nacreous markings on the posterior margin of the pronotum and thoracic pleurites. Posterior margin of the pronotum abruptly elevated to form a flat flanged border thus making the pronotum subsellate when viewed in lateral profile. Tegmina longer than the pronotum but not extending to the apex of the abdomen. Wings plectate or fan-like, when unfolded pale bluish green with irregular bands of black and sometimes chrome-yellow. Legs moderately to strongly spinose. Fore and middle femora with 6-10 pairs of small or large spines; caudal femora with 10-14 pairs of small or large spines. Fore tibiae with 6 pairs of very long teeth and 4 or 5 outer dorsal teeth. Meso-tibiae with 6 pairs of long ventral teeth and 3 to 4 outer and 4 inner shorter dorsal teeth. Caudal tibiae with long rows of paired dorsal spines (immovable) and fewer ventral teeth (in sockets and movable). All the sternites with toothed lobes. Cerci strong and usually uncinate with an internal proximal prominence or tooth.

Genotype.—Rehnia victoriae Caudell.

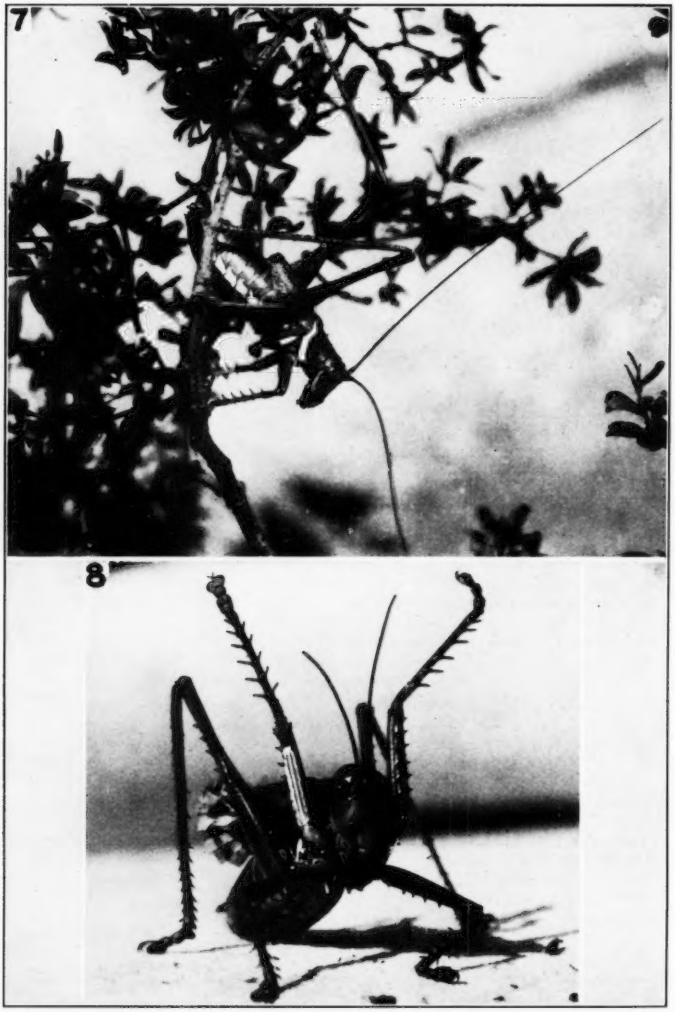
KEY TO THE SPECIES OF REHNIA

1. Size large; femoral spines of all legs large and conspicuous 2
   Size medium to small; femoral spines of all legs small and inconspicuous 3
2. Cerci long, simple, falcate, with a long acuminate and gently incurved point and without an internal basal projection or tooth. Color of wing unknown but probably pale bluish green with irregular bands of black ..... *spinosus*
   Cerci long and uncinate, the apex sharply incurved and with a stout internal tooth just basad of center. Wings large, plectate, when unfolded pale bluish green with irregular band composed of rectangular patches of blackish brown ..... *cerberus*
3. Size medium, outer margins of wings not distinctly bordered with chrome-yellow 4
   Size small, wing pale bluish green with irregular central bars of black and with the outer borders chrome-yellow. Cerci bluntly uncinate with a small internal basal tooth or projection ..... *pulchellus* n. sp.
4. Tegmina greenish with apex uniformly green; wings pale bluish-green with large central patch of shining black. Cerci strongly uncinate with an internal basal projection ..... *victoriae*
   Tegmina testaceous with apex infuscated with cellular patches of brownish black; wings atrophied, pale bluish green sparsely marked with small spots of black. Cerci uncinate with a large internal proximal tooth ..... *sinaloae*

REHNIA VICTORIAE Caudell

1907. *Rehnia victoriae* Caudell. Proc. U. S. Nat. Mus., **32**:306, fig. 14-15.
1931. *Rehnia victoriae* Hebard. Proc. Acad. Nat. Sci. Phila., **83**:202 (Kansas).
1932. *Rehnia victoriae* Hebard. Trans. Amer. ent. Soc. **58**:337.

Coloration.—This handsome creature is uniformly foliage green with the entire raised posterior margin of the pronotum nacreous or pearly white. Wing plectate, when unfolded and fan-like a little less than one-half inch



Figs. 7. Male *Rehnia victoriae* perched in an alert position in Creosote Bush.
Fig. 8. Male *Rehnia cerberus* portraying aggressive habits and ready to fight.

long, pale bluish green with a large central shining black patch which sometimes has a small spot of pale green invading it. Femoral spines short and green and not black as in *cerberus* and *spinosus*. See Fig. 7.

Biology.—The life history has not been worked out or studied but as the adults mature in mid-summer and an occasional nymph is taken at that time it would appear that the nymphs probably appear in the early spring. This species spends its entire life in bushes or trees. The ova are of the same form as grasshopper eggs and thus are markedly different from the flat reniform-shaped ova of the Leaf Katydids. However, the ova lack the cap characteristic of acridid eggs and do not possess the cellular sculpturation of the acridid chorion. The egg is fairly long and lengthily oval, shining, pearly lilac in coloration and with the chorion or egg shell sparsely impunctate with shallow depressions.

Habits.—*Rehnia victoriae* is thamnophilous or bush dwelling and nocturnal. When captured or annoyed it is distinctly aggressive, raising its fore-legs in the air, spreading its beautiful wings and ready to fight.

Food Plants.—The host plant depends largely upon the type of vegetation in any particular region. As *Rehnia* is partly carnivorous its food does not depend strictly upon the vegetation. In captivity *R. victoriae* takes readily to grasshoppers. The principal host plant is mesquite. In the sand dune region near Monohans and Odessa, Texas, the host plant was *Prosopis glandulosa*. East of Sanderson some fifteen miles it was taken in Blackbrush *Flourensia cernua* and at Eagle Pass in a black-stemmed *Acacia* sp. At Laredo it was in mesquite *Prosopis glandulosa* and in a canyon near Cuidad Victoria, Mexico, the host was *Karwinskia humboltiana*.

Song.—The song is baffling to interpret into words. The closest approach seems to be a "zeee-e-e-e-t — zeee-e-e-e-t — zeee-e-e-e-t" repeated in rapid continuous succession. One listening can hear the "t," "z," "e-e-e," and "t" in the short space of slightly more than half a second. At 80 degrees Fahrenheit the writer timed 106 "t-zeee-e-e-e-t's" per minute which is probably the maximum rate as the insect could not possibly produce them with much more celerity. The song is long and sustained often continuing for half an hour or more without a pause unless disturbed. The song can be heard for a distance of 100 feet or more depending upon the sharpness of a person's hearing. Should, however, the would-be captor stalk this Katydid, he seldom gets closer than 10 feet without being heard. Occasionally the males sing in the bright sunlight.

Records.—Sand dunes near Monohans and Odessa, Texas, Oct. 2, 1931. TEXAS: 4 ♂; Eagle Pass, Texas, Aug. 14, 1940, 2 ♂; 15 miles E. of Sanderson, Aug. 14, 1940, 1 ♂; Laredo, Aug. 15, 1940, 1 ♂; Sept. 10, 1940, 1 ♂ (E. R. Tinkham). 1 ♀, Camp Barkeley nr. Abilene, July 29, 1942 (E. R. Tinkham). Coahuila: Recorded from Monclova, the female type locality, by Hebard, in 1932. Tamaulipas: Canyon, 3 miles west of Cuidad Victoria, Aug. 31, 1940, 1 ♂; 34 miles South of Linares, Aug. 31, 1940, 1 ♀ (E. R. Tinkham).

Distribution.—The type locality is Cuidad Victoria for the male and Monclova, Coahuila for the female. *Rehnia victoriae* is a member of the

Lower Sonoran fauna occupying in Mexico and southern Texas the Tamaulipan Semi-Desert Bushland formation. Its range extends northward up the Pecos Valley to the extreme southwestern corner of Kansas (Hebard 1939), and east to central Texas.

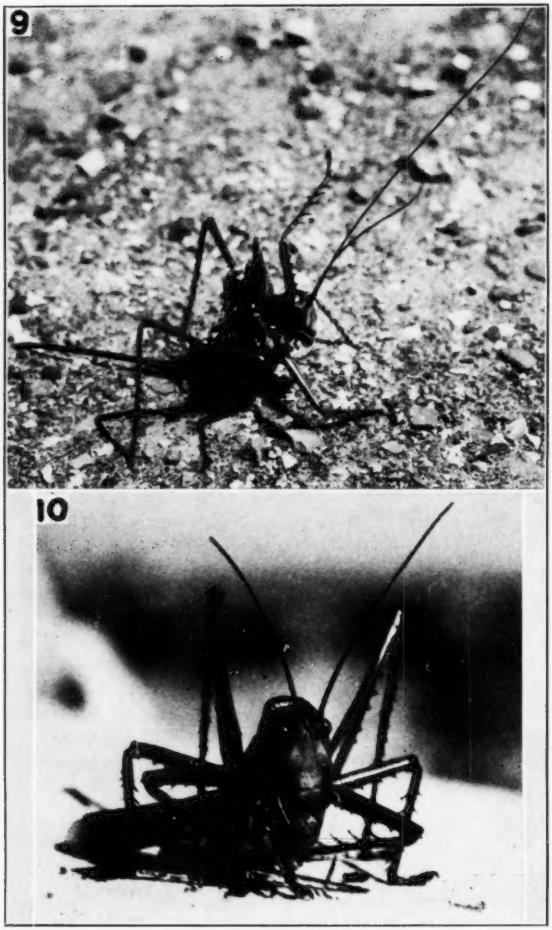


Fig. 9. Female *Rehnia cerberus* in fighting attitude.
Fig. 10. Male *Rehnia cerberus* feeding on grasshopper.

REHNIA SPINOSUS Caudell

1907. *Rehnia spinosus* Caudell. Proc. U. S. Nat. Mus., **32**:307, fig. 16.

This large species with long black spines on all the legs is known only from the unique type male described from "Texas." The male cercus is distinctive and separates it from the large *R. cerberus*. Its distribution is not known because there is some question as to the validity of the locality "Texas" based on Bruner's word. The species is probably a Mexican form or it may well be one restricted to the tropical coast of the Gulf of Mexico since all the *Rehnia* occupy different floral formations with no overlapping in their distribution.

REHNIA CERBERUS Rehn and Hebard

1920. *Rehnia cerberus* Rehn and Hebard. Trans. Amer. ent. Soc., **46**:234, figs.

1932. *Rehnia cerberus* Hebard. Trans. Amer. ent. Soc., **58**:337.

Coloration.—Deep foliage green with nacreous markings on the posterior margin of the pronotum broken by a spot of brownish at the humeral angles. Pleurites of the thorax with broad stripes of nacreous. Abdominal sternites with a paired row of large round whitish spots in the living specimen, these spots obsolete in the preserved specimen. Wings large, plectate, when unfolded fan-like and three-quarters of an inch in length, pale bluish green with four irregular and sometimes partially fused narrow blackish bands composed of quadrangular spots (see Fig. 11).

Habits.—Shortly after my arrival on the desert of southwestern Texas and still a stranger to desert life, I was collecting in the Ruidoso Hot Springs Canyon some fifty miles northwest of Presidio, the evening of October 14, 1928. About sundown I heard the song of a Katydid in a nearby Mesquite and cautiously approached. Later the specimen was identified as *Rehnia cerberus*. At that time I knew nothing concerning the habits of these creatures. Approaching the specimen I planned to catch it in my fingers for it was about five feet off the ground, and I did not have a net. When my hand was slowly approaching and about six inches away *Rehnia* suddenly assumed an interesting and menacing attitude. Its spiny forelegs were held high above its head, mantid-like (see Fig. 8), its antennae held back and its beautiful mottled pale green and black wings spread fan-wise to each side and its mandibles were bared. Suddenly without warning it gave a few rapid "tszicks," jumped to the end of my finger and gave me a vicious nip, then quickly dropped to the ground and crawled under a cactus plant growing in the clump of mesquite. Such aggressiveness took me completely by surprise as it was all over in a few seconds. The mouse had attacked the elephant, a katydid a man a thousand times his size. Undaunted and rather vexed at this sudden turn in events, I crawled in under the mesquite and managed to retrieve my prize, the first male *Rehnia cerberus* I had ever seen. Truly it is well named for Cerberus in Greek mythology was the dog of Hercules that guarded the Gates to Hyades. This aggressive trait is commonly exhibited by this species, in an instant, whenever it is touched or annoyed. In this position it is really

a creature of elegance and pride. The females exhibit this same trait as is shown by Fig. 9.

Host.—Although dwelling in mesquite and other bushes and trees, and phyllophagous, this species is probably more inclined to cannibalism. It readily devours weaker members of its own kind and voraciously feeds on grasshoppers (see Fig. 10), and probably other species of insect life that it should find in its home-tree. The species is nocturnal but I have taken specimens sunning themselves in the top of a creosote bush in the early morning hours. The writer has taken this species principally in mesquite (*Prosopis chilensis*), Creosote (*Larrea divaricata*) and rarely in *Karwinskia humboltiana* on the periphery of its range.

Biology.—The life history is not known but as the writer has taken nymphs in September it would seem that the eggs hatch in the spring and the adults are mature in July, August or sometimes September. The egg is pearly lilac-grey in color, 6.5 mms. long and 1.5 mms. wide and is slightly larger than that of *R. victoriae*. It is not known whether the adults survive the winter but they are found until November. One female had 54 mature ova.

Song.—The song of *cerberus* is closely similar to that of *victoriae* but is a stronger "tszeee-e-e-k — tszeee-e-e-k — tszeee-e-e-k" rapidly repeated and continued indefinitely until disturbed.

Records.—Texas: Chinati Mts., 4 miles south of Shafter, Sept. 27, 1931, 8 ♂; Sept. 30, 1928, 1 ♀; Ruidoso Hot Springs, Presidio Co., Oct. 14, 1928, 1 ♂; Haciendita, 9 miles NW. Presidio, Sept. 10, 1928, 1 ♂; Presidio, Sept. 9, 1928, 1 ♀ nymph; 20 miles north of Chisos Mts., July 18, 1930, 1 ♀ nymph (all E. R. Tinkham). Marfa, Texas, 1 ♀ (G. Goddholt). Nuevo Leon: 28 miles NW. Monterrey near Coahuila boundary, Sept. 9, 1940, 1 ♂ (E. R. Tinkham). These are the first Nuevo Leon records. Coahuila: 42 miles NW. Saltillo (en route Torreon), Sept. 3, 1940, 4 ♂, 1 ♀, 1 ♀ nymph; 6 miles north Parras, Sept. 4, 1940, 2 ♂ (E. R. Tinkham). First Coahuila records. Chihuahua: Reported from Jarral, by Hebard, in 1932.

Distribution.—*R. cerberus* is a member of the Lower Sonoran faunal region and is restricted to the Chihuahuan Desert tract. On the east is found *R. victoriae* and to the south on the Salado Desert a new species of *Rehnia* is found. The Nuevo Leon record is the southeastern limital point in its distribution and the southeastern corner of the Chihuahuan Desert in this area.

REHNIA SINALOAE Hebard

1920. *Rehnia sinaloae* Hebard. Trans. Amer. ent. Soc., **46**:240.

1932. *Rehnia sinaloae* Hebard. Trans. Amer. ent. Soc., **58**:337.

Coloration.—Size about that of *R. victoriae*, green in color with only the lateral margins of the pronotum pearly white. Tegmina with the apex more rounded than in the other species of *Rehnia*, reddish brown with the intercellular areas beyond the speculum brown. Wings atrophied and very small, pale greenish brown with small round blackish spots between the veins.

Biology.—Nothing is known concerning the life history of this species.

Song.—Similar to the other species of the genus.

Habits.—This species does not show the aggressive characteristics of *cerberus* and it is probably more phyllophagous than carnivorous, because the femoral spines in this species are very minute.

Host Plant.—The two males were taken in a clump of the Sonoran plant *Franseria ambrosioides,* which is probably one of its host plants. Fig. 13 shows two males on *Franseria ambrosioides.*

Record.—The types were described from Vendidio, Sinaloa, by Hebard, in 1920. The two males taken 40 miles north of Hermosillo, Sonora, Nov. 1, 1939 by the writer are the first for the state of Sonora.

Fig. 11. Male *Rehnia cerberus* with wings expanded (left) and female (right).

Distribution.—*R. sinaloae* is a member of the Lower Sonoran fauna and is known from Sinaloa north to 40 miles north of Hermosillo. It is probably a member of the Sinaloan Thorn Forests which merge with the flora of the Sonoran Desert in the region of the Yaqui River.

Rehnia pulchellus n. sp.

This is the smallest species of the genus and is most closely allied to *Rehnia victoriae* Caudell. It is readily distinguished from all other species in the genus by having the outer third of the wings beyond the irregular black markings, chrome-yellow (see Fig. 12, no. 6.). In addition the tibiae and tarsi of all legs are tinged with vinaceous differing thus from the green tibiae and tarsi of the other four species.

Type.—♂, 4 miles north of Escondida, Sw. Nuevo Leon, elevation approximately 6400 feet, August 26, 1940 (E. R. Tinkham; night collecting). Measurements in millimeters: body length 21.0; pronotum 5.6 x 4.0 wide; tegmina 9.5; wings 8.5; caudal femora 20.0. Type in the Tinkham Collection.

Description.—Form typical for the genus; size small. Pronotum with the posterior half of the metazonal disk uptilted and making the pronotum appear subsellate in lateral profile; anterior margin of pronotum with perceptible flanged effect. Tegmina abruptly narrowed beyond the middle with acute apex. Forelegs with fore femora bearing 6 inner and 8-9 outer short ventral spines (immovable); fore tibiae with 6 pairs of long ventral teeth (movable in sockets) and 4 outer dorsal teeth. Middle legs with meso-femora with 6 inner and 8-10 outer short ventral spines; meso-tibiae with 6 pairs of long stout ventral teeth and 3 outer and 5 inner long dorsal teeth. Caudal femora with 9-10 outer and 10-11 inner very short spines on ventral keels; caudal tibiae with 24 outer and 21-23 inner dorsal spines (ventral side in folded leg), and 12-14 outer and 10-11 inner ventral teeth. All the sternites with the typical toothed lobes. Cerci, stout, uncinate, with a median internal prominence.

Coloration.—Deep foliage green with the lateral posterior margins of the pronotum nacreous, narrowing to a line on the humeral angles. Wings beautifully marked, pale green with an irregular shining black band formed of coalesced quadrangular black marks beyond which, the outer third of the wing is margined with chrome yellow. Tibiae and tarsi of all legs tinged with vinaceous and crimson lake.

Allotype.—♀, same date as the Type. Measurements in millimeters: body length 22.5; pronotum 6.2; tegmina 11.5; caudal femora 24.5; ovipositor 33.0. Type in the Tinkham Collection.

Description.—Features and coloration same as the Type but size slightly larger. Ovipositor long, strong and very gently decurved.

Paratypes.—2 ♂, same date as the Type; 1 ♂, 7 miles east of Matehuala, San Luis Potosi, August 22, 1940. Range in measurements in millimeters: body length 21.0-24.0; pronotum 5.2-5.8; tegmina 11.5; hind femora 20.0-

22.0. Male paratypes similar to the Type in all respects. 2 ♀, same date as the allotype.—Range in measurements in millimeters: body length 21.0-23.0; pronotum 5.8-6.5; tegmina 12.0-12.5; hind femora 22.5-26.0; ovipositor 31.0-33.0. Female paratypes similar to the allotype.

Biology.—These are not known but are probably similar to the other species of *Rehnia*.

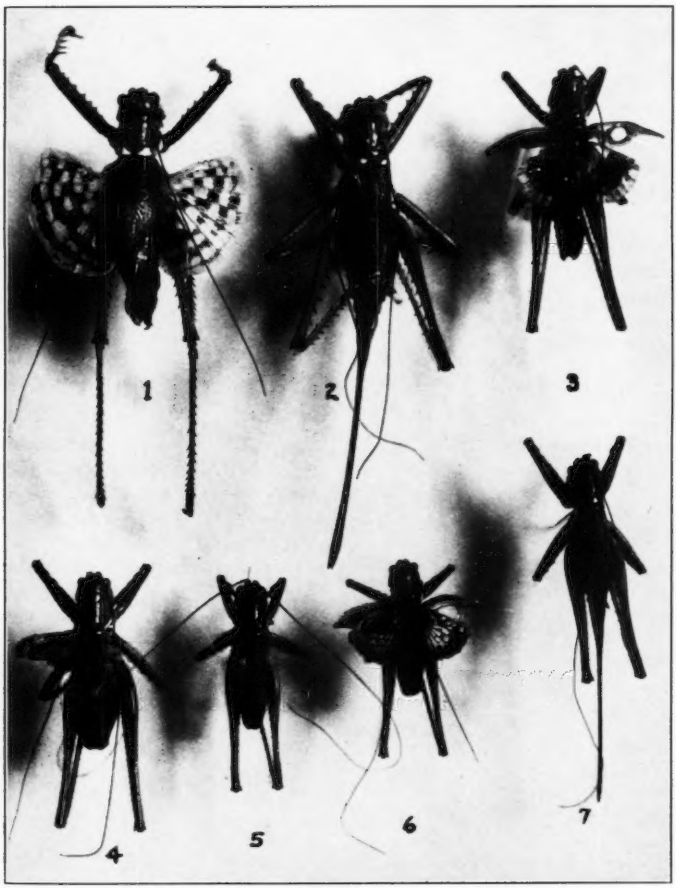


Fig. 12. Showing species of *Rehnia*. 1-2. Male and female *Rehnia cerberus*. 3. Male *Rehnia victoriae*. 4. Male *Rehnia sinaloae*. 5. Male Paratype *Rehnia pulchellus* n. sp. 6. Male Type *Rehnia pulchellus* n. sp. 7. Female Allotype *Rehnia pulchellus* n. sp.

Habits.—Like other species of *Rehnia* this species is thamnophilous dwelling in trees and bushes. It is carnivorous as well as phyllophagous and nocturnal. One female contained 18 maturing ova.

Song.—The song of this small and interesting species is a moderately strong and continuous "tszik-tszik-tszik" that can be heard for fifty feet or more. The song is quite ventriloquistic and the species is located with great difficulty. The writer was able to locate only one or two specimens in the thorny vegetation during an hour's night collecting by sound and flashlight. This species starts to sing at sunset and the song continues throughout the night until the following sunrise. The writer was fortunate in locating three females and a male on a Cactus plant shortly after dawn. Daylight singing often occurs.

Host Plants.—The Matehuala male was found singing during the afternoon in a species of *Lycium*. Some of the Escondida specimens were found hiding on a species of *Opuntia* or Prickly Pear, one male was in *Acacia berlandieri* and a female was taken in *Karwinskia humboltiana*.

Distribution.—Known only from Matehuala, San Luis Potosi and Escondida in southwestern Nuevo Leon, this small species inhabits the southern portions of what is recognized as the Salado Desert.

ZYCLOPTERA Caudell

1907. *Zycloptera* Caudell. Proc. U. S. Nat. Mus., **32**:308.

Size large and rather heavy; head broad and moderately deep. Eyes subcircular and subglobular and very widely spaced. Occiput convex and fastigium low and flat with rounded lateral margins. Pronotum broad and flat with broadly rounded lateral margins and very gently convex posterior margin. Tegmina slightly longer than the pronotum with the inner margin straight and the outer margin subcircularly rounded. Fore and middle femora with a few minute spines; caudal femora with keel spineless. Fore and middle tibiae with 6 pairs of widely spaced short ventral teeth and 3 outer dorsal spines on the fore tibiae and 2 outer and 4 inner dorsal teeth on the meso-tibiae. Caudal tibiae with 10-12 widely spaced short outer teeth and 13 inner teeth on the dorsal surface and 6-7 minute outer and small inner teeth on the ventral side. Ovipositor long, greater than the length of the caudal femora and distinctly decurved. Prosternites with a pair of minute teeth, meso- and meta-sternites with raised and dentate lateral margins.

Genotype.—*Zycloptera atripennis* Caudell.

ZYCLOPTERA ATRIPENNIS Caudell

1907. *Zycloptera atripennis* Caudell. Proc. U. S. Nat. Mus., **32**:309, figs. 1819. (♂ type, Hawthorne, Nevada).

Coloration.—Body color pale to darker stone grey with white lateral margins to the pronotum and the posterior half of the lateral lobes. Tegmina bister with cream-colored encrustations sprinkled over their surface. Abdomen

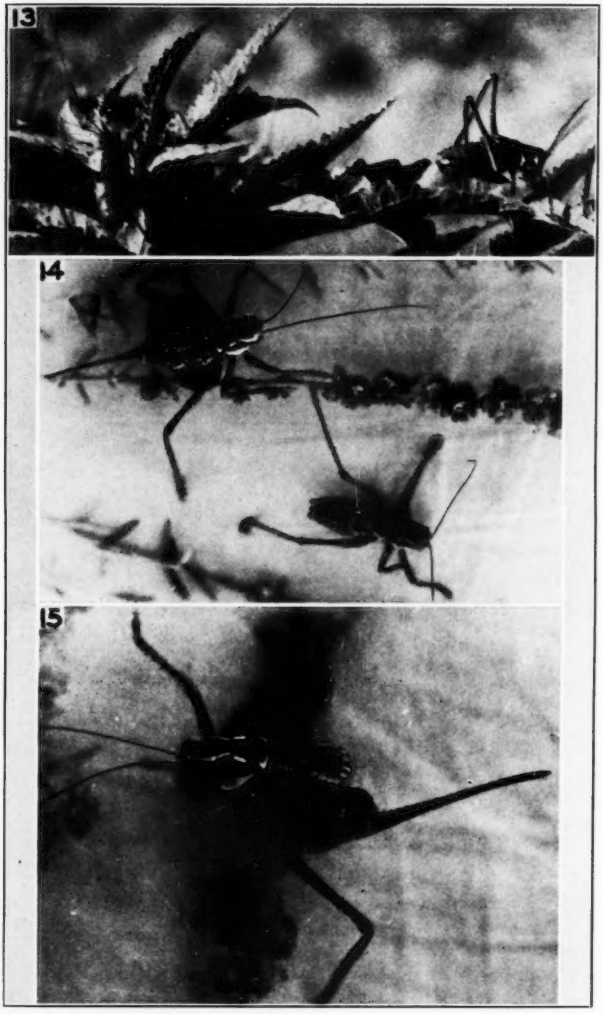


Fig. 13. Showing two males of *Rehnia sinaloae* on host plant *Franseria ambrosioides*.

Fig. 14. Showing male and female of *Zycloptera atripennis*.

Fig. 15. Female *Zycloptera atripennis* in aggressive attitude, with black wings partly exposed.

varying shades of stone gray with dorso-lateral and lateral lines irregularly marked with white. Wings plectate and shining jet black, hence the specific name of *atripennis*. Legs and thoracic and abdominal sternites soft stone gray.

Biology.—The life history of this species is not known. The eggs probably hatch in the early spring and the adults mature in middle or late summer.

Habits.—*Z. atripennis* is nocturnal and thamnophilous and herbivorous. When gutted for preservation the mesenteron contained the remains of the flowers of *Atriplex confertifolia*. Although exhibiting aggressiveness when annoyed by raising its front legs or the fore and middle legs on one side and spreading its shining jet black wings (see Figs. 14 and 15) there is no evidence to suggest that this species is carnivorous. Seven specimens were kept in a jar for several weeks without losing a specimen due to cannibalism.

Song.—At a distance the song of *Z. atripennis* is closely similar to *Capnobotes fuliginosus* but on closer approach the song is softer and somewhat like "zi-i-i-k — zi-i-i-k — zi-i-i-k." It is long continued.

Host Plants.—In its habitat at the south end of Walker's Lake, Nevada, hard clay flats with ridges of sand probably marking different beach levels, were dominated by *Atriplex confertifolia* and *Sarcobatus vermiculatus* and a few other plants one of which was a skeleton weed. The four females and three males were taken in *Atriplex confertifolia, Sarcobatus vermiculatus* and the skeleton weed of unknown identity.

Records.—South end Walkers Lake, Nevada, August 14, 1938, 4 ♀, 3 ♂ (E. R. and G. E. Tinkham).

Distribution.—This very large and rare creature is known only from the type locality, Walkers Lake, Nevada. It is a member of the Great Basin Desert fauna. *Z. atripennis* is probably a relic of Pleistocene days when the Great Basin was a mass of great lakes. It survived to the present day probably because Walkers Lake is the sole remnant of far larger lakes of the Pleistocene Period in this region.

AGLAOTHORAX Caudell

1899. *Tropizaspis* Scudder (pt.). Proc. Amer. Acad. Sci., **35**:83-87.
1907. *Aglaothorax* Caudell. Proc. U. S. Nat. Mus., **32**:290.
1920. *Aglaothorax* Rehn and Hebard. Trans. Amer. Ent. Soc., **46**:225.

This remarkable genus is quickly recognized by the enormous size of the pronotum which covers fully half of the body in this Shield-back Katydid. The lateral constrictions come immediately behind the anterior margin of the pronotum, the lateral carinae sharp and diverging strongly posteriorly to round evenly into the strongly convex posterior margin of the pronotum. Tegmina completely hidden by the shield-like pronotum. Fore and middle femora with or without a few small spines. Caudal femora with 7 to 8 small outer and 2 to 3 small inner spines on the lower keels. Fore tibiae with 6 small pairs of ventral teeth and a pair of small apical dorsal teeth. Middle tibiae with 6 small pairs of ventral teeth and one inner basal and one outer apical dorsal teeth. Caudal tibiae armed with long rows of spines on the dorsal surface;

ventral side with 4 or 5 small widely spaced paired teeth. Cerci small, pseudocerci or infracercal plates long, laterally compressed with a black subapical spine on the inner surface. Subgenital plate large; thoracic sternites unarmed. Ovipositor long, recurved, with the apical third of the dorsal valvulae finely serrate.

Genotype.—*Tropizaspis ovata* Scudder.

KEY TO THE SPECIES OF AGLAOTHORAX

1. Disk of the pronotum large, ovally rounded with the lateral keels gently convex; disk heavily etched with shining black. Body color green with white black and reddish brown markings.....east slope of Sierra Nevadas *segnis*
   Disk of pronotum smaller with the lateral keels parallel or subparallel. Colors duller; size smaller 2
2. Lateral margins of the posterior half of the pronotum parallel. Lateral lobes of prozona without black markings .....Nevada *armiger*
   Lateral margins of the posterior half of the pronotum diverging caudally. Colors mainly brown. Lateral lobes of the prozona with brown below keels .....mts. of S. Calif. *ovatus*

AGLAOTHORAX OVATUS (Scudder)

1899. *Tropizaspis ovata* Scudder. Proc. Amer. Acad. Sci., **35**:83.

1900. *Tropizaspis ovata* Scudder. Cat. Orth. U. S., p. 77.

1902. *Tropizaspis ovata* Woodworth. Bull. 142, Calif. Exp. Sta., p. 15.

1906. *Tropizaspis ovata* Kirby. Syn. Cat. Orth., **2**:191.

1907. *Aglaothorax ovatus* Caudell. Proc. U. S. Nat. Mus., **32**:291, Fig. 2-3.

Coloration.—General color castaneous, contrasting sharply with the bright green, black and white coloration of *A. segnis* of the Sierra Nevadas. The size is also smaller than that species and the lateral margins of the pronotum divergent posteriorly. In *ovatus* the disk of the pronotum is pale brownish with black etchings only on the posterior margin and with fine streaks of darker brown striating the disk. Lateral lobes of the prozona with brown just ventrad of the lateral keels; this marking is not present in *segnis* or *armiger*. The abdomen is brownish, mottled profusely with darker brown.

Biology.—Nothing is known concerning these.

Habits.—*A. ovatus* is nocturnal and thamnophilous or arboreal, dwelling in bushes and sometimes tall Western Yellow Pines or in Oak trees. When captured this species plays "possum" and feigns death by drawing its head under its body as far as is possible and drawing all legs together. This species is herbivorous.

Song.—The song of ovatus is a strong "zip-zip" broken by a pause of several seconds and quite distinct from the "zic-zic-zic" of *segnis*. It can be heard for about one hundred feet. Some males were singing high up in the Western Yellow Pines of the San Gabriel mountains near Big Pines, the night of August 25, 1938. Others were in oaks and two of these were captured.

Fig. 16. Showing camouflage effect of markings of two male *Aglaothorax segnis* (3/5 nat. size) on host plant *Cowania stansburiana*. Sierra Nevadas, California.

Fig. 17. Showing two males of *Aglaothorax armiger* (9/10 nat. size) on pine limb. Charleston Peak, Nevada.

Fig. 18. Female *Plagiostira albonotata* (9/10 nat. size) resting in bush.

Host Plant.—Western Yellow Pine (*Pinus ponderosa*) and Oaks, probably *Quercus kelloggi* are hosts of this species. This species is not aggressive and appears to be strictly phyllophagous.

Records.—The type locality is Los Angeles County with no particular locality given. It has also been recorded from the San Bernardino mountains. San Gabriel mts., near Big Pines, top of mountain, Aug. 25, 1938, 2 ♂ (E. R. Tinkham).

Distribution. — Known at present from the San Bernardino and San Gabriel mountains of southern California.

AGLAOTHORAX SEGNIS Rehan and Hebard

1920. *Aglaothorax segnis* Rehn and Hebard. Trans. Amer. ent. Soc., **46**:225.

Coloration.—This species is without question one of the most beautiful of the North American Decticinae. The sides of the body are pale green flecked with small white dots and the dorsum of the abdomen possesses a rather broad median band of raw sienna bordered with white. On the second, fourth and fifth abdominal segments this white occupies rather large triangular patches. The purpose of this white is to break up the markings of the body to render the insect inconspicuous and the black etchings on the pronotum acting as shadows also serves this purpose (see Fig. 16 for illustration of this protective camouflage). The very large shield-like pronotum is cream-colored striated with pale brown and streaks of black and heavily etched with black along the margins and the central portions of the pronotum. The antennae are black annulated with white. The fore and middle legs are greenish with a preapical band of reddish brown or blackish on the femora. Caudal femora with the dorsal apical half blackish with a broad central band of cream separating the black areas.

Biology.—The life history of this species is not known. The adults are present from August until freeze-up in November but it is not likely that they survive the cold weather. The eggs probably hatch with the warm spring weather and the adults appear in August or late July.

Habits.—This beautiful creature is arboreal or thamnophilous living in small pine trees or small shrubs. When captured or touched it feigns death. The adults are strictly nocturnal hiding down in the depths of the dense bushes during the day. The adults are strictly phyllophagous and do not attack one another. No aggressive traits are exhibited by members of this group.

Song.—The song of *A. segnis* is a strong "zic — zic — zic — zic" or "zic — zic — zic" the number of "zics" depending upon the individual katydid, some making four, others three; three being the common number. Each series is interrupted by a pause of several seconds during which another individual on the mountain side will probably answer the song. The "zicing" continues from sundown long into the night. Each series of "zics" lasts about a second.

Host Plants.—In the Wakers Pass the host was Tree Yuccas *Yucca brevi-*

folia and at Carrol Creek west of Lone Pine in 1931, the chief host was *Pinus monophylla*. At the mouth of Lone Pine Creek the Sagebrush *Artemisia tridentata* was the chief host and in Big Pine Canyon *Cowania stansburiana*, Apache Plume, was favored with Sagebrush second in importance.

Records.—Big Pine Canyon, 9 miles west Big Pine, Calif., Aug. 16, 1938, 30 ♂, 1 ♀; Oct. 22, 1939, 6 ♂. Lone Pine Canyon, 11 miles west Lone Pine, Calif., Aug. 17, 1938, 5 ♂; Oct. 21, 1939, 2 ♂. Carrol Creek, 9 miles west Lone Pine, Aug. 5, 1931, 14 ♂, 1 ♀ (E. R. Tinkham; Hebard Cln). Walkers Pass, Calif., August 22, 1938, 13 ♂ (all E. R. Tinkham).

Distribution.—*A. segnis* occupies a zone roughly 4500 to 5500 feet in elevation at the east base of the Sierra Nevadas. This zone extends from Walker Pass, marking the south extremity of the Sierra Nevadas north to Big Pine Creek, and probably north to Rock Creek but no collecting has been made at this locality. The zone occupied is chiefly *Artemisia tridentata* and west of Lone Pine is at the very base of the Sierra Nevadas. Further north the zone is a few miles east of the base and south at Walker Pass the zone is the Yucca zone at the top of the pass.

AGLAOTHORAX ARMIGER Rehn and Hebard

1920. *Aglaothorax armiger* Rehn and Hebard. Trans. Amer. ent. Soc., **46**:229, figs.

Coloration.—Size smaller than *A. segnis;* pronotum smaller and narrower with the lateral keel in the posterior half almost parallel. Pronotal margins etched with black, and black borders the white areas on the dorsum of the abdomen; this black is absent in *A. segnis* and *A. ovatus*. Coloration otherwise similar to the genus.

Biology.—Probably the same as the other species but unknown.

Habits.—These are similar to the other members of the genus.

Song.—The song is a strong "zic — zic — zic" rapidly repeated with a brief pause between each series of "zics." The song can be heard for almost two hundred feet. This species is very wary and one must make several cautious approaches before the singing katydid can be spotted.

Host Plants.—At the mouth of the Canyon leading into Charleston Peak from Las Vegas the writer found this species in the Tree Yuccas, *Yucca brevifolia;* others were singing in *Pinus monophylla* but were impossible to locate because of their ventriloquistic song. Further up the canyon, this species is sometimes rarely taken in the lower branches and on the trunks of *Pinus ponderosa,* and Fir.

Records.—Charleston Peak Canyon, elev. 7500 feet, Aug. 15, 1931, 1 ♂ (E. R. Tinkham; in fir; Hebard Cln.). Mouth of Charleston Peak Canyon in Yucca-Pinon-Juniper zone on desert, Oct. 20, 1939, 2 ♂ (E. R. Tinkham).

Distribution.—*A. armiger* is known only from Charleston Peak Canyon, the type locality, and is a member of the Yucca-Pinon-Juniper Zone.

NEDUBA Walker

1869. *Neduba* Walker. Cat. Derm. Salt. Br. Mus., **2**:250.
1874. *Arytropteris* Hermann. Verh. Zool.-Bot. Ges. Wien, **24**:204 (pt.).
1893. *Tropizaspis* Brunner. Ann. Mus. Civ. Stor. Nat. Genova, **33** (2d ser., 13):187 (invalid as no species included).
1894. *Tropizaspis* Scudder. Can. Ent., **26**:178-180.
1902. *Tropizaspis* Woodworth. Bull. 142, Calif. Exp. Sta. p. 14.
1906. *Neduba* Kirby. Syn. Cat. Orth., **2**:194.
1906. *Tropizaspis* Kirby. Syn. Cat. Orth., **2**:194.
1907. *Neduba* Caudell. Proc. U. S. Nat. Mus. **32**:295.

Neduba is closely related to *Aglaothorax* but is smaller in size and with much smaller pronotum; disk of the pronotum smaller and oval in outline. Constriction of the lateral keels slightly more caudad than in *Aglaothorax*. Tegmina completely covered by the pronotum. All femora spineless; fore tibiae with 7 pairs of ventral spines and 1-2 dorsal teeth, though often spineless. Middle tibiae with 8 pairs of ventral teeth and 3 outer and 4 inner dorsal basal teeth. Caudal tibiae with two long rows of dorsal spines, and 2-3 widely scattered minute teeth on the ventral surface. Supra-anal plate usually quadrate and not rounded as in *Aglaothorax;* subgenital plate large. Cerci small; pseudocerci long, laterally compressed and lacking inner subapical tooth in the larger species. Sternites without toothed lobes. Ovipositor long, shorter than the caudal femora, recurved with the apical portions of the dorsal valvulae with finely serrate margin.

Genotype.—Neduba carinata Walker.

KEY TO THE SPECIES OF NEDUBA

1. Size very small; pseudocerci with an internal subapical tooth; tegmina uniformly purplish brown ..... *morsei*
   Size normal and much larger; pseudocerci without internal subapical teeth; tegmina whitish, sometimes with clouded apex 2
2. Maximum breadth of the pronotum more than 7 mms. 3
   Maximum breadth of the pronotum less than 7 mms. 4
3. Disk of the pronotum castaneous, body color pale castaneous gray; tegmina whitish with infuscated apex. Outer angles of the quadrate supra-anal plate square.... *convexa*
   Disk of the pronotum brownish often striated with fine streaks of black; tegmina whitish gray with a black patch at the apex. Outer angles of the supra-anal plate acute angled. ..... *carinata*
4. Color uniformly gray; size larger ..... *diabolicus*
   Color grayish with the sides of the thorax and abdomen with much black; size smaller ..... *sierranus*

NEDUBA CARINATA Walker

1869. *Neduba carinata* Walker. Cat. Derm. Salt. B. M., **2**:251.
1874. *Arytropteris steindachneri* Hermann. Verh. Zool.-Bot. Ges. Wien, **24**:204, pl. 6, fig. 98-102.
1894. *Tropizaspis steindachneri* Scudder. Can. Ent., **26**:182-183.
1899. *Tropizaspis steindachneri* Scudder. Proc. Amer. Acad. Arts Sci., **35**:84, 86.
1900. *Tropizaspis steindachneri* Scudder. Cat. Orth. U. S., p. 77.

1902. *Tropizaspis steindachneri* Woodworth. Bull. No. 142, Calif. Exp. Sta., p. 15.
1906. *Neduba carinata* Kirby. Syn. Cat. Orth., **2**:194.
1906. *Tropizaspis steindachneri* Kirby. Syn. Cat. Orth., **2**:194.
1907. *Neduba carinata* Caudell. Proc. U. S. Nat. Mus., **32**:296, fig. 6-7.
1922. *Neduba carinata* Buckell. Proc. Ent. Soc. Br. Col. **20**:30.
1929. *Neduba carminata* Fulton. Pan-Pac. Ent., **5**:175-180, 16 figs.

Coloration.—Fulton who has written considerably about this species recognized three color phases. In the first phase the pronotum was immaculate, the second was lightly marked and third phase was heavily marked with black on the dark tan-colored pronotum. These color forms are found in any particular habitat and are probably the insect's response to environmental colorations. The general body coloration is brownish or grayish profusely mottled with fine fleckings of black. The tegmina are distinctive, grayish white with the apex possessing a blackish gray patch that serves to distinguish this species.

Biology.—What is known concerning the biology of this species has been given by Mr. B. B. Fulton. There are six nymphal instars separable by the length of the pronotum and the development of the male and female genitalia. The nymphs appear in the fall and live through the winter hiding in the leaves, and in mid-summer become adults. The adults feign death when captured or disturbed. The species is nocturnal, thamniphilous on the east side of the Sierra Nevadas and sylvan in the forests of Oregon.

Habits.—Mr. Fulton has called this katydid the "Camouflage Cricket" because of the remarkable manner this creature has of hiding or making itself inconspicuous on the forest floor of its home in Oregon. The species is nocturnal, sylvan in Oregon and thamnophilous at the east base of the Sierra Nevadas in Owens Valley. When disturbed or captured this insect feigns death.

Song.—The song of *Neduba carinata* cannot be mistaken for that of the genus *Aglaothorax*. Song is a soft "Tst-zee-e-e-e — tst-zee-e-e-e — tst-zee-e-e-e" long continued and heard for a distance of twenty to thirty feet. The "tst" is produced by the drag or return of the tegmina to natural position and the "zee" is the sound stroke. Sometimes the song sounds like "tst-zing-g-g-g" or "t-t-t-tszingggg — t-t-t-tszinggggg" the "t-t-t" produced by the teeth of the tegmina as they return to natural position for the next stroke. The latter sound is made at lower temperatures. This species sings at fairly cool temperatures in late October when winter is approaching the Sierra Nevadas.

Host Plant.—At Mono Lake the writer took this species in *Pinus monophyllus* in 1930 and in *Artemisia tridentata* in 1938. In Big Canyon *Cowania stansburiana*, Apache Plume, was the favored host. A sumac-like plant with small blue berries growing in spikes, is particularly attractive to this species and other Desticids in late August or early September. At Lone Pine Canyon this species was rare but found in *Artemisia*.

Records.—Big Pine Canyon, Aug. 16, 1938, 11 ♂; Oct. 22, 1939, 12 ♂. Lone Pine Canyon, Aug. 17, 1938, 6 ♂, Oct. 21, 1939, 1 ♂, Aug. 13, 2 ♂, 1 ♀. Mono Lake, mouth of Tioga Pass, Aug. 11, 1938, 9 ♂, Aug. 1, 1931, 6 ♂, 1 ♀ (E. R. Tinkham; Hebard Cln.). All specimens taken by E. R. Tinkham.

Distribution.—Known on the east slopes of the Sierra Nevadas Lone Pine Creek to Mono Lake in the Pine Zone above the *Artemisia* zone; at Mono Lake this zone is lower than at Lone Pine. The lower limits of *N. carinata* merge with the upper limits of the *Aglaothorax segnis* zone and in this intergrading zone the two species may be found. The distribution of *N. carinata* probably continues north to the Lake Tahoe region and then swings to the western slopes of the mountains as the species is known from Hood River and Rogue River, Oregon (Fulton) and north to the Okanagan Valley, British Columbia (Buckell).

NEDUBA CONVEXA Caudell

1907. *Neduba carinata* var. *convexa* Caudell. Proc. U. S. Nat. Mus., **32**:300, fig. 9-10.
1909. *Neduba convexa* Rehn and Hebard. Proc. Acad. Nat. Sci. Phila., p. 475.

Coloration.—The body color in this species is castaneous gray and pronotum is castaneous. The size is slightly larger than *N. carinata* and the ovipositor of the female longer.

Biology.—The life history is unknown but probably similar to other species of the genus.

Habits.—Similar to other species of *Neduba.*

Song.—Almost indistinguishable from *Neduba carinata.*

Host Plant.—In the Walker Pass near the summit this species was found only in Tree Yuccas *Yucca brevifolia.*

Records.—Walker Pass, California, elev. 5,000 feet, Aug. 22, 1938, 5 ♂, 3 ♀ (E. R. and G. E. Tinkham).

Distribution.—The Type Locality is Mt. Shasta. Rehn and Hebard (1909 recorded specimens from Mt. Tamaulipas. The species probably ranges south along the western slopes of the Sierras to Walker Pass.

NEDUBA SIERRANUS (Rehn and Hebard)

1909. *Aglaothorax sierranus* Rehn and Hebard. Proc. Acad. Nat. Sci. Phila., p. 476, fig. 15-19.

Coloration.—Although described as an *Aglaothorax,* this species is a Neduba not only on account of its features but on the nature of its song. This is the second smallest species of the genus as is characterized by the black markings on the lateral lobes of the pronotum and on the sides of the abdomen. The pronotum and median area of the dorsum of the abdomen is pale brownish with fine mottling of darker brown.

Habits.—This species is arboreal, dwelling in pine trees in the Yosemite region. Other habits are similar to *Neduba.*

Song.—The song of *N. sierranus* is soft and low and audible for a short distance only. The song is similar to other species of *Neduba.*

Host Plant.—This species was found only in a species of Pine at Carl Inn, Yosemite, California.

Records.—Carl Inn, Yosemite Park, Aug. 12, 1938, 2 ♂ (E. R. Tinkham).

Distribution.—This species is known only from the Yosemite Park region.

NEDUBA DIABOLICUS (Scudder)

1899. *Tropizaspis diabolica* Scudder. Proc. Amer. Acad. Arts Sci., **35**:84, 86.
1900. *Tropizaspis diabolica* Scudder. Cat. Orth. U. S. p. 77.
1902. *Tropizaspis diabolica* Woodworth. Bull. No. 142. Calif. Exp. Sta., p. 15.
1906. *Tropizaspis diabolica* Kirby. Syn. Cat. Orth., **2**:191.
1907. *Aglaothorax diabolicus* Caudell. Proc. U. S. Nat. Mus., **32**:294.

Coloration.—This interesting species is distinguished by its uniform color of medium or dark grayish brown. The tegmina are grayish white and immaculate. The fore and middle femora have preapical bands of black.

Habits.—Similar to other species of *Neduba* but less sensitive to light at night, some specimens kept on stridulating with the light of a flashlight shining on them.

Biology.—Nothing is known concerning the life history of this species.

Song.—The song of *N. diabolica* is quite distinct from the other species of the genus. Song of about the same intensity as *Neduba carinata* but continuous with the "zwees" interrupted with a "tck" as the tegmina come back into position. Song is a continuous "zwee-tck — zwee-tck — zwee-tck — zwee-tck — zwee-tck."

Host Plant.—Probably oaks as the species was found in amongst the leaves and small bushes at the base of oaks.

Records.—Tehachapi mts., Paradise Valley, Aug. 6, 1931, 7 ♂, (E. R. and H. A. Tinkham; Hebard Cln.).

Distribution.—The unique female type was described from Mt. Diablo. The species is known from Mt. Diablo south to the Tehachapis.

NEDUBA MORSEI Caudell

Neduba morsei Caudell. Proc. U. S. Nat. Mus., **32**:301, fig. 11.

Coloration.—This, the smallest species in the genus, is either uniformly buffish brown or dark grayish; if grayish the specimens are lightly mottled with flecks of black with a small amount of black just ventrad of the lateral keels of the pronotum. The tegmina are purplish brown and the pseudocerci or infra-cercal plates are long and narrow with a minute internal apical tooth.

Biology.—Nothing is known concerning these.

Habits.—This small species is nocturnal and thamnophilous, feeding on the leaves of the plants which are their home.

Song.—Quite distinct and peculiar as it does not resemble any other of the other various species of *Neduba* and *Aglaothorax*. The song is a "Tsip-tsip-tsip-tsip-tsip-tsip-tsip" continuing strong and finishing weaker and lower, then broken by a pause, then shortly the song is repeated.

Host Plant.—In the San Gabriel mountains this species was found only in the shining and waxy-leaved shrub called Yerba Santa (*Eriodictyon californicum*).

Records.—San Gabriel Mts., Big Pines, Aug. 25, 1938, 8 ♂, 1 ♀ (E. R. and G. E. Tinkham). Olympic Mts., Wash., July 18, 1926, 1 ♂ (R. Flock).

Distribution.—The type locality of this species is Mount Wilson, Altadena, California. *N. morsei* is known from the mountains of southern California north along the Pacific Coast west of the high Sierras to the Olympic mountains of Washington.

PLAGIOSTIRA Scudder

1876. *Plagiostira* Scudder. Ann. Rept. Chief. Eng., p. 501.
1894. *Plagiostira* Scudder. Can. Ent., **26**:179, 182.
1897. *Plagiostira* Scudder. Guide Orth. N. Amer., p. 57.
1906. *Plagiostira* Kirby. Syn. Cat. Orth., **2**:195.
1907. *Plagiostira* Caudell. Proc. U. S. Nat. Mus., **32**:388.

This species is characterized by its medium size, rather long and slender form and the peculiar form of the pronotum. The pronotal disk is flat with concavities, the pronotal keels strong and parallel and present except on the anterior fifth; the lateral lobes are shallow; the shape of the pronotum squarish or rectangular. Thorax with only the mesosternites armed with a pair of small spines. Fore and middle femora lacking ventral spines; caudal femora with 3 to 4 internal spines on the ventral keel. Fore tibiae with 6 pairs of ventral teeth and 1 to 2 dorsal outer ones. Mesotibiae with 6 pairs of ventral teeth. Caudal tibiae with 12 outer and 14 inner widely spaced dorsal spines and 7 outer and inner ventral teeth. Ovipositor considerably longer than the caudal femora and distinctly decurved.

Genotype.—*Plagiostira albonotata* Scudder.

PLAGIOSTIRA ALBONOTATA Scudder

1876. *Plagiostira albonotata* Scudder. Ann. Rept. Chief Eng., p. 501.
1876. *Plagiostira albonotata* Scudder. Rept. U. S. Geol. Surv. W. 100th Mer., p. 281.
1900. *Plagiostira albonotata* Scudder and Cockerell. Proc. Davenp. Acad. Nat. Sci. **9**:55.
1903. *Plagiostira albonotata* Caudell. Proc. U. S. Nat. Mus., **26**:807.
1904. *Plagiostira albonotata* Scudder. Can. Ent., **26**:182.
1906. *Plagiostira albonotata* Kirby. Syn. Cat. Orth., **2**:195.
1907. *Plagiostira albonotata* Caudell. Proc. U. S. Nat. Mus., **32**:389, Fig. 74-76.
1907. *Plagiostira albonotata* var. Brevipes, Proc. U. S. Nat. Mus., **32**:392.
1929. *Plagiostira albonotata albonotata* Hebard. Proc. Acad. Nat. Sci. Phila., p. 492.
1935. *Plagiostira albonotata* Hebard. Trans. Amer. Ent. Soc., **61**:310.

Synonymy.—Hebard placed the variety *brevipes* in synonymy, in 1935.

Coloration.—Body color grayish green; legs and ovipositor pale green. Head pale green with a white streak just below the eye and the lower margin of the genae; dorsum of head with two narrow chalk white stripes between the eyes. Pronotum grayish green with the lateral keels tinged with lavender and with three pairs of chalk white spots on the dorsum; one pair on the front margin, another pair centrally placed and just within the lateral keels with a small narrowly separated pair of spots just cephalad of this central larger pair.

Biology.—This has not been described. The eggs probably hatch in the early spring with the advent of warm weather as nymphs are still present in mid-July. These nymphs are females whereas the males, having one less stadium than the females, are adult at this time. The eggs are pale violet gray 6.2 mms. long and 1.45 mms. in width. The twenty eggs are laid singly. The chorion under high power shows small impressed areas, each with a microscopic pore in the center.

Habits.—This species is thamnophilous, dwelling in bushes on eastern section of the Great Basin desert. It is nocturnal and at night work up to the tops of the Rabbit brush bushes where they feed on the leaves, or in the fall on the petals of the yellow flowers which are highly favored for food. This species does not exhibit any aggressive features, nor does it appear to have any cannibalistic traits.

Song.—The song of *P. albonotata* is a soft "zee-e — zee-e — zee-e" continuous and audible for a distance of thirty to forty feet.

Host Plant.—The chief host plant appears to be Rabbit Brush *Chrysothamnus* spp., the katydid feeding on the leaves but in the fall is especially attracted to the petals of the small yellow flowers. Occasionally specimens are found in the Arrow-weed *Pluchea sericea* and in Sagebrush *Artemisia tridentata.*

Records.—The type female was described from New Mexico. Caudell, in 1907, studied specimens from Dolores and Durango, Colorado; Pinedale, Arizona and Albuquerque, New Mexico. The variety *brevipes* was described from Williams, Arizona. The University of Arizona contains specimens ranging from the Kaibab to Shiprock and the Grand Canyon to Springerville. Winslow, Arizona, Sept. 22, 1939, 4 ♂, 2 ♀; Petrified Forest, Arizona, July 15, 1940, 6 ♂, 2 ♀ last instar nymphs (E. R. Tinkham). Ten miles East Flagstaff, Ariz., July 26, 1931, 1 ♀ (E. R. Tinkham; Hebard Cln.).

Distribution.—*Plagiostira albonotata* occupies the southeastern corner of the Great Basin Desert. Its range extends from Durango and Dolores, southwestern Colorado, east to Albuquerque, New Mexico, south to Springerville, Pinedale, and Winslow, and west to Williams, the Kaibab Plateau, and Kanab, Utah.

PLAGIOSTIRA GILLETTEI Caudell

1907. *Plagiostira gillettei* Caudell. Proc. U. S. Nat. Mus., **32**:392, fig. 77.
1929. *Plagiostira gillettei* Hebard. Proc. Acad. Nat. Sci. Phila., **81**:403.

Coloration.—The coloration in this interesting species is yellow-brown with the sunken area of the pronotum greenish and the posterior margins of

the abdominal segments edged with round black spots. This species is easily distinguished from its relative *P. albonotata* by its larger size and much broader and almost square pronotum.

Biology.—The life history of this species has not been described, but is probably similar to that of *P. albonotata.*

Habits.—Nocturnal and thamnophilous, living in sagebrush, and strictly phyllophagous.

Song.—The song of this species is not known.

Host Plant.—These have not been described but are probably similar to those of *P. albonotata,* chiefly Rabbit brush and Sagebrush.

Records.—The only published record is the type, a juvenile male, from Grand Junction, Colorado. The writer has a female from Price, Utah, collected by Miss Grace O. Wiley, in 1923, but it is not available for study. The species is also known from Nevada.

Distribution.—This species inhabits the eastern section of the Great Basin Desert, occupying an area in eastern Utah and extreme western Colorado, north of the range of *Plagiostira albonotata.*

ATELOPLUS Scudder

1894. *Ateloplus* Scudder. Can. Ent., **26**:179, 182 (invalid; no spp. desc.).
1897. *Ateloplus* Scudder. Guide N. Amer. Orth., p. 57 (invalid).
1900. *Ateloplus* Scudder. Cat. Orth. U. S., p. 79, 98.
1906. *Ateloplus* Kirby. Syn. Cat. Orth., **2**:195.
1907. *Ateloplus* Caudell. Proc. U. S. Nat. Mus., **32**:368.

This genus includes species of large to small size and of rather uniform tan, brown or gray coloration. The pronotum is short, almost square, the posterior margin squarely truncate and the disk of the pronotum broadly rounded into the shallow lateral lobes. Caudal femora short, heavy, and strongly swollen in the basal half. Male tegmina exposed for less than half the length of the pronotum; not exposed in the female. Fore and middle femora unarmed or with a few small ventral spines; caudal femora with one to five small internal spines on the lower keel. Fore tibiae with 6 pairs of ventral spines and 1 to 3 outer dorsal teeth; meso-tibiae with 6 pairs of ventral and usually 2 outer and 4 inner dorsal teeth. Caudal tibiae with two long dorsal spine rows of variable number and a few widely spaced ventral teeth. Ovipositor short, heavy and gently recurved; cerci generally slender with an incurved or subapical prong, acutely pointed.

Genotype.—Ateloplus notatus Scudder.

There are seven known species; the first male of *A. minor* will be described in the following pages.

KEY TO THE MALES OF ATELOPLUS

1. Size very large for the genus; pronotal length exceeding 8 mms. ..... *splendidus*
   Size medium to small; pronotal length less than 7 mms. 2

2. Size medium to small; cerci almost as broad as long with a short toothed inner prominence 3
Size small; much longer and narrower with an apical or subapical toothed prong directed inwards 4
3. Color uniformly brown; outer and apical margins of the cerci acute-angled; size fairly large ..... *schwarzi*
Color mottled dark grayish; outer and apical margins of the cerci obtuse-angled; size small ..... *minor*
4. Cerci with the inner prong subapical in position ..... *coconino*
Cerci with the inner prong apical in position 5
5. Supra-anal plate squarely truncate with a slight median concave notch ..... *notatus*
Supra-anal plate with a deep "U"-shaped notch 6
6. Size very small, dark gray with pale gray dorso-lateral shadings on the pronotum and abdomen ..... *hesperus*
Size small; usually light tan, sometimes tinged with gray, with or without a dorsal median black chain-like marking ..... *luteus*

ATELOPLUS NOTATUS Scudder

1900. *Ateloplus notatus* Scudder. Cat. Orth. U. S., pp. 79, 98, pl. 2, fig. 3.

1906. *Ateloplus notatus* Kirby. Syn. Cat. Orth., **2**:195.

1907. *Ateloplus notatus* Caudell. Proc. U. S. Nat. Mus., **32**:369, figs. 54, 55.

Coloration.—General coloration uniform reddish brown with a black median stripe on the pronotum and a heavy black chain-like stripe down the dorsum of the abdomen. The genicular areas of the caudal femora are infuscated.

Biology.—The particular life history has not been described. Like other species the ova mature in late summer and are laid and hatch the following spring.

Habits.—This interesting species is nocturnal and terrestrial.

At night it is found crawling about on the desert floor of its home, but when disturbed exhibits great saltatorial powers and are thus not easily captured.

Song.—The song is a soft low "zee-zee-zee-zee-zee" that is inaudible at fifteen feet or more.

Host Plant.—These are not known. As the species wanders out over the desert floor it may be partly scavangering for small bits of organic material that it can find.

Records.—Six miles east of Jacumba, California, Aug. 24, 1931, 3 ♂, 6 ♀ (E. R. and G. E. Tinkham; Hebard Cln.). The Type locality is San Diego and Caudell recorded an immature male from Indio.

Distribution. — The Jacumba specimens were taken where the Pinon-Juniper Zone merged with Creosote and other desert plants. This species is restricted to Southern California and is a member of the Colorado Desert fauna.

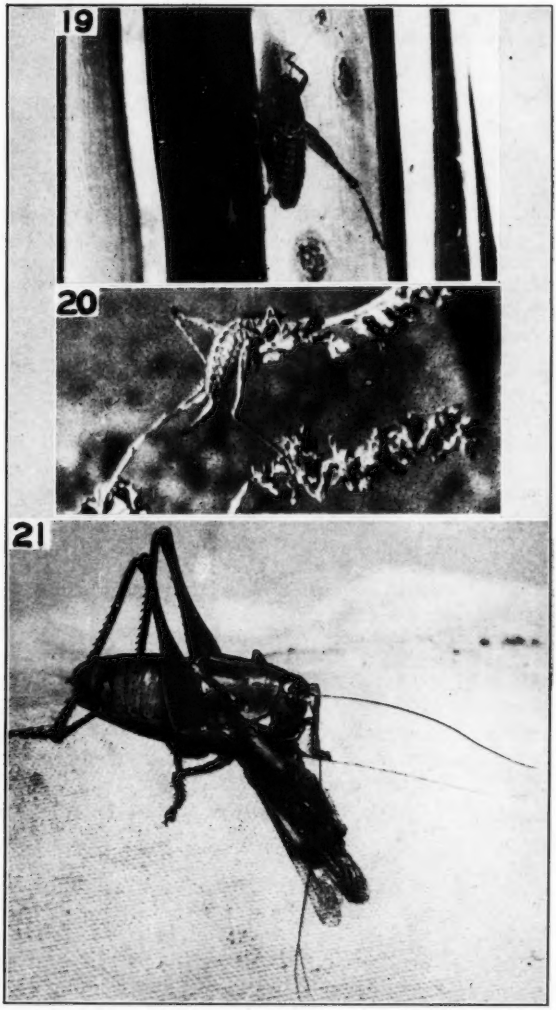


Fig. 19. Allotype male of *Ateloplus minor* (nat. size) on hanging leaves of *Yucca Schottii*.

Fig. 20. Topotype female of *Ateloplus hesperus* (nat. size) on host plant, *Artemisia tridentata*.

Fig. 21. Showing male *Pediodectes americanus* (nat. size) feeding on a grasshopper.

ATELOPLUS MINOR Caudell

1907. *Ateloplus minor* Caudell. Proc. U. S. Nat. Mus., **32**:371, fig. 56.

Caudell described this species from a single female taken at Oracle, Arizona, June 29 (Schwartz).

As the male is undescribed I present below the description of the male type.

This species in size is about that of *A. notatus* but differs by being darker gray and lacking the dorsal median black stripe. It is evidently most closely allied to *A. schwarzi* from which it differs by much smaller size, darker gray coloration and the shape of the cerci; which is quite different from all the species of the genus except *schwarzi* by its breadth. From *schwarzi* the cerci is distinguished by having the outer and apical cercal margins obtuse-angled and not acute angled as in that species.

Allotype.—♂, Santa Rita Mountain, near mouth of Madera Canyon, Sept. 2, 1938 (E. R. Tinkham; *Yucca Schottii*). Measurements in millimeters: body length 18.5; pronotum 5.3 x 3.75 in width; exposed tegmina 2.0; caudal femora 13.5 x 3.6 in basal breadth; antennae c. 32.0 mms. Allotype in the Tinkham Collection.

Description.—Size moderately small, form typical for the genus. Posterior margin of the pronotum straight and very slightly concave due to the posterior half of the metazona having a perceptible upward tilt. Fore and middle legs stout; caudal femora short, exceeding the apex of the abdomen by one-third its length; the base strongly swollen. Fore femora with the lower keels spineless; meso-femora with one outer apical spine; caudal femora with 5 to 6 outer and 3 to 5 inner short black spines on the lower keels. Fore tibiae with 6 pairs of stout ventral teeth; meso-tibiae with 6 pairs ventral and 1 outer and 4 inner dorsal teeth; caudal tibiae with 27-28 outer and 20-22 inner dorsal spines, those on the basal half alternately small and large, the small spine at the proximal base of the large spine, and 6 outer and 6 inner small widely spaced ventral teeth. Cerci short and broad with the outer and apical cercal margins obtuse-angled and the inner apex toothed.

Coloration.—Gray mottled profusely with darker gray on the dorsum of the body. Face and thoracic pleurites pale gray finely mottled with flecks of darker gray. Tegmina dull black with the principal veins testaceous. Fore and middle femora with a dark pre-genicular annulus. Caudal femora mottled gray, darker on the dorsal surface and with the swollen basal half bearing a median black stripe on the outer pagina. Caudal tibiae mottled gray with a dark basal annulus. Fig. 18 shows the male type on the dry pendant leaves of (*Yucca Schottii*).

Biology.—These are not known, but observations would lead one to believe that the eggs hatch in the spring and the adults are mature in late July or early August.

Habits.—The species is nocturnal and likes to hide in the pendant leaves of Yuccas.

Song.—The song is a soft low "zeee — zeee-zeee-zeee" continuous and audible for a distance of ten to fifteen feet. The male type was taken singing at midnight.

Host Plant.—The male type was taken in *Yucca Schotti.*

Records.—Only the unique male type is known.

Distribution.—The female was described from Oracle at the north base of the Santa Catalina mountains and the male type from Madera Canyon in the Santa Ritas, some seventy-five miles to the south of the first locality. *A. minor* inhabits the lower levels of the Sonoran Live Oak Zone in Arizona; this zone merges with the desert vegetation of the Sonoran Desert.

ATELOPLUS SCHWARZI Caudell

1907. *Ateloplus schwarzi* Caudell. Proc. U. S. Nat. Mus., **32**:372, figs. 57, 58.
1935. *Ateloplus schwarzi* Hebard. Trans. Amer. Ent. Soc., **61**:312.

Coloration.—In coloration this species most closely resembles *A. notatus* but it is considerably larger and lacks the black median, dorsal chain-like marking characteristic of *A. notatus.*

Biology.—These remain to be described.

Habits.—*A. schwarzi* is nocturnal, sometimes found on the desert floor, on other occasions found in bushes or perched upon the roof of a pack-rat's den.

Song.—The song of *A. scwarzi* is a faint soft trill "zee — zee — zee — zee — zee" that cannot be heard at more than ten feet distance.

Host Plants.—One male was taken singing in an *Acacia* bush and others were taken on top of a pack rat's nest. This species probably feeds on organic material rather than on the leaves of microphyllous desert plants.

Records.—The Type locality is Tinajas Altas in southwestern Arizona. Caudell (1907) also reports specimens from Phoenix, Hot Springs, Santa Rita mountains. Specimens taken in the Gila Bend Mountains, August 29, and the Maricopa mountains, August 28, 1931, by the writer, are in the Hebard Collection.

Distribution.—*A. schwarzi* is a member of the Lower Sonoran fauna restricted to the Sonoran Desert east of the Colorado River.

ATELOPLUS LUTEUS Caudell

1907. *Ateloplus luteus* Caudell. Proc. U. S. Nat. Mus., **32**:373, fig. 59.

Coloration.—The prevailing color in this small species is a light tan, although some individuals exhibit a faint gray band on the sides of the body, and rarely an individual with dark gray banding.

Biology.—Nothing is known concerning the life history of this small species.

Habits.—This species is nocturnal and thamnophilous, hiding in small

desert bushes such as species of *Atriplex*. It is believed that this species is strictly herbivorous in food habits.

Song.—Like other species of the genus, the song of *A. luteus* is a faint low "zee-zee-zee-zee" continuous until disturbed and audible for only a few feet.

Host Plants.—At Walker Lake, Nevada, this species was found in *Atriplex confertifolia*. Other host plants probably include other species of *Atriplex* of which there are many species.

Records.—Walker Lake, near Hawthorne, Nevada, August 14, 1938, 5 ♂, 3 ♀; Walker Pass, California, elev. 4800 feet, Aug. 22, 1938, 5 ♂, 6 ♀ (E. R. and G. E. Tinkham).

The type locality is Mojave, California.

Distribution.—*A. luteus* is a member of the Mojave Desert and is known from Mojave and Walker Pass, California, east and north to Walker Lake, Nevada.

ATELOPLUS HESPERUS Hebard

1934. *Ateloplus hesperus* Hebard. Trans. Amer. ent. Soc. **60**:40 (Lone Pine Canyon, California).

Description.—This, the smallest species in the genus *Ateloplus* is distinguished by its small size and dark gray coloration. The dorso-lateral areas are pale gray and there is a dorsal median chain-like stripe running from the fastigium of the head to the apex of the abdomen. The female ovipositor is gently recurved and about the length of the caudal femora.

Biology.—These are unknown for this rare species.

Habits.—This diminutive species is nocturnal and thamnophilous, hiding in dense clumps of sagebrush during the day. It is strictly herbivorous or phyllophagous on the leaves of desert plants.

Song.—The song of this small creature is very faint and cannot be heard at distance greater than a few feet. It is a faint buzzing "zee-zee-zee-zee."

Host Plant.—This species has been found only in Sagebrush *Artemisia tridentata* as illustrated by Fig. 20.

Records.—In addition to the male and female type from Lone Pine Canyon and a female paratype from near Cosa Hot Springs, both in Owens Valley, and in the Hebard Collection, the writer possesses the following specimens: two female topotypes dated Aug. 14, 1938, and 1 female topotype dated Oct. 21, 1939 (E. R. Tinkham). In addition the writer possesses one male and one female taken in Big Pine Canyon, August 16, 1938 (G. E. Tinkham).

Distribution.—The range of this small rare species is restricted to Owens Valley at the east base of the Sierra Nevadas. It is a member of the Mojave Desert fauna.

ATELOPLUS SPLENDIDUS Hebard

1934. *Ateloplus splendidus* Hebard. Trans. Amer. ent. Soc. **60**:43, Pl. 2, fig. 3; Pl. 3, fig. 4 (Barstow, California).

Coloration.—This is by far the largest and handsomest species of the genus *Ateloplus*. Its general coloration is gray mottled with darker gray. The lower half of the lateral lobes of the pronotum are conspicuously marked with ochraceous buff. The dorsum of the pronotum and abdomen is pale gray with a median chain-like stripe of dark grey.

Biology.—The life history of this rare species is unknown.

Habits.—This large species is nocturnal and thamnophilous, dwelling in desert vegetation upon which it feeds. It is not known whether the various species of *Ateloplus* show any cannibalistic traits.

Song.—Singing commences in the evening about sundown. The song is distinctive and loud and rapid. The writer timed this species and found it to make 180 distinct "zees" per minute. The song is a long sustained "zee — zee — zee — zee — zee — zee — zee" produced at a very rapid rate and continued for many minutes at a time.

Host Plant.—This species was taken on *Larrea tridentata,* the Creosote bush, which is its host.

Records.—The original type male specimens were taken on the desert near Barstow, California, August 10, 1931 by the writer and his brother. Nr. Barstown, Aug. 23, 1938, 1 ♂ (E. R. Tinkham).

Distribution.—*A. splendidus* is a member of the Lower Sonoran faunal region occupying the Colorado Desert. The female type came from near Coyote Wells in Imperial Valley, California.

ATELOPLUS COCONINO Hebard

1935. *Ateloplus coconino* Hebard. Trans. Amer. ent. Soc., **61**:140, pl. VII, fig. 1-2.

1935. *Ateloplus coconino* Hebard. Trans. Amer. ent. Soc., **61**:311 (listed).

Coloration.—In coloration and size this species is closely similar to *A. notatus* but differs in lacking the black dorsal stripe and by the feature of the male cerci which has the internal prong subapical and not apical as in *A. notatus.*

Biology.—The biology of this species is not known.

Habits.—These are probably similar to *A. notatus.*

Song.—The song has not been described but it is probably a low faint "zee-zee-zee-zee" continuous and similar to other small species of *Ateloplus.*

Food Plants.—The host plant of this species has not been described. It may dwell in Yuccas that are found in the vicinity and north of the type locality.

Records.—The type locality is Bill Williams Fork, Arizona and I have been fortunate in examining a topotype male from that locality.

Distribution.—*A. coconino* is a member of the Lower Sonoran Faunal region and a member of the Mojave Desert, which finds its eastern limits in this region just east of the Colorado River.

PEDIODECTES Rehn and Hebard

1897. *Orchesticus* Scudder. Guide. Orth. N. Am., p. 55.
1900. *Orchesticus* Scudder. Cat. Orth. U. S., p. 76.
1900. *Stipator* Rehn. Trans. Amer. Ent. Soc., **27**:90.
1904. *Stipator* Rehn. Proc. Acad. Nat. Sci. Phila., p. 543.
1906. *Stipator* Kirby. Syn. Cat. Orth., **2**:183.
1907. *Stipator* Caudell. Proc. U. S. Nat. Mus., **32**:339.
1920. *Pediodectes* Rehn and Hebard. Trans. Amer. Ent. Soc., **46**:244.

This genus is characterized by species of medium to large size and of rather heavy build. Pronotum rather long, about one and three-quarters times as long as broad. Disk of pronotum flat, the lateral margins smoothly rounding into the deep lateral lobes, the posterior margins of which are concavely sinuate. Tegmina partially exposed in the males and concealed by the pronotum in the females. Prosternum with toothed lobes; meso- and meta-sternites with triangulate lobes. Fore femora with one to two ventral spines; meso-femora unarmed; caudal femora with 6 to 8 small black spines on the lower inner keel. Fore tibiae with 6 pairs of ventral teeth and two outer and 0-1 inner dorsal teeth; meso-tibiae with 6 pairs of ventral teeth and 2 outer and 4 inner dorsal teeth. Caudal tibiae with about 26 outer and 24 inner dorsal spines and 6 pairs of ventral widely spaced teeth. Ovipositor about two-thirds the length of the caudal femora.

Genotype.—Orchesticus americanus Saussure.

Ten species of *Pediodectes* are known, five of which, namely: *prattei, stevensoni, haldemanii, daedalus* and *nigromarginata* are species of the Great Plains and do not come within the scope of this treatise. Of the other five species, *P. ateloploides* from Baja California is known only from the type female, and may not belong to this genus.

KEY TO THE SOUTHWESTERN SPECIES OF PEDIODECTES

1. Face of uniform coloration 2
   Face crossed by a band of white bordered with black 3
2. Body coloration green or yellowish green. Metazona of the pronotum verona brown with median and lateral stripes of buffish white ..... *americanus*
   Body coloration dark mottled brownish black; caudal femora large and bearing an inner dorso-lateral and an outer median stripe of dark brown; size large.... ..... *grandis*
3. Face and genae black and crossed by a white band (one sixteenth inch wide), gently decurved, and running from posterior margin to posterior margin of the head ..... *tinkhami*
   Face only with a white triangular patch edge with black, posterior margin of genae whitish ..... *bruneri*

PEDIODECTES AMERICANUS (Saussure)

1859. *Orchesticus americanus* Saussure. Rev. Mag. Zool., **11**:201.
1869. *Orchesticus americanus* Walker. Cat. Derm. Salt. B. M., **2**:248.
1894. *Orchesticus americanus* Scudder. Can. Ent., **26**:180, 183.

1900. *Orchesticus americanus* Scudder. Cat. Orth. U. S., p. 76.
1900. *Stipator americanus* Rehn. Trans. Amer. Ent. Soc., **26**:90.
1906. *Stipator americanus* Kirby. Syn. Cat. Orth., **2**:183.
1907. *Stipator americanus* Caudell. Proc. U. S. Nat. Mus., **32**:341, figs. 41-42.
1920. *Pediodectes americanus* Rehn and Hebard. Trans. Amer. Ent. Soc., **46**:245.

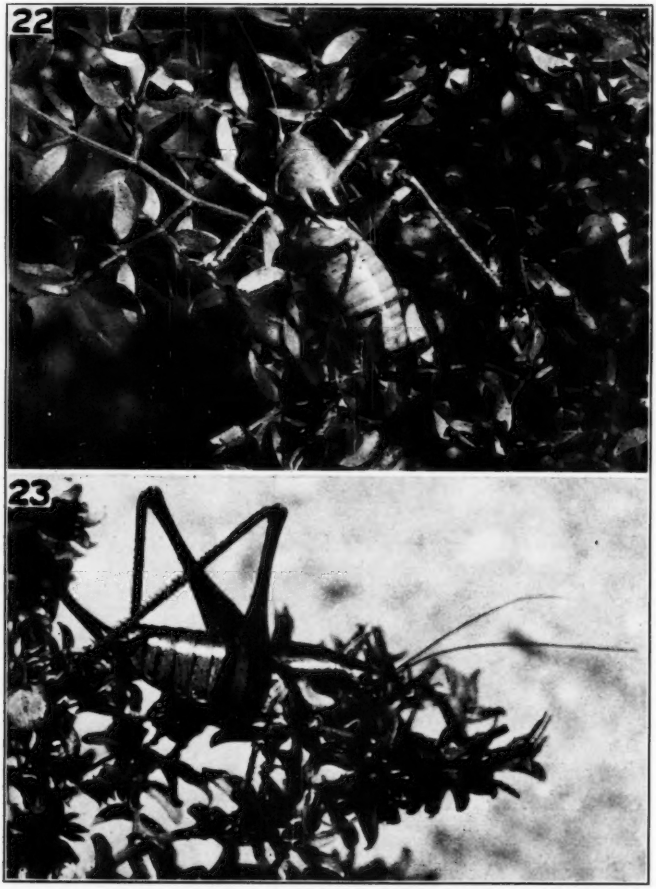


Fig. 22. Male *Pediodectes americanus* (nat. size) resting on Creosote bush.
Fig. 23. Showing female *Pediodectes grandis* (nat. size) from Ciudad Victoria, Tamaulipas.

Coloration.—This species is quickly identified by its uniform yellowish-green coloration with the posterior portion of the disk of the pronotum dark verona brown with median and lateral stripes of buffish white.

Biology.—According to Caudell adults appear as early as May in Texas; otherwise there is nothing published on its life history.

Habits.—This species is thamnophilous, dwelling in bushes and small trees. It is phyllophagous and nocturnal and when in captivity quickly attacks grasshoppers and other insects offered to it (see Fig. 21). It does not exhibit any aggressiveness for when annoyed this creature tries to escape by jumping.

Song.—The song of *P. americanus* is a soft "tsee — tsee — tsee — tsee" that is continuous and can be heard for a distance of thirty to forty feet. When disturbed the species remains quiet for many minutes before resuming its singing.

Host Plant.—At Ozona, near the western edge of the Edwards Plateau this species was found in Mesquite (*Prosopis glandulosa*).

Records.—Ozona, Texas, Sept. 12, 1940, 4 ♂ (E. R. Tinkham; mesquite).

Distribution. — This species is known from the western edge of the Edwards Plateau, east to central Texas and north to northern Texas.

PEDIODECTES GRANDIS (Rehn)

1904. *Stipator grandis* Rehn. Proc. Acad. Nat. Sci. Phila., pp. 544-545.
1906. *Stipator grandis* Kirby. Syn. Cat. Orth., **2**:183.
1907. *Stipator grandis* Caudell. Proc. U. S. Nat. Mus., **32**:347.
1920. *Pediodectes grandis* Rehn and Hebard. Trans. Amer. Ent. Soc., **46**:246.
1932. *Pediodectes grandis* Hebard. Trans. Amer. Ent. Soc., **58**:338.

Coloration.—This very large and handsome species is quickly recognized by its size and dark brown coloration with the upper two-thirds of the lateral lobes of the pronotum dark mahogany brown and the lower third pale buffish brown. The caudal femora are very large and strongly swollen in the basal half with the outer pagina heavily marked with blackish brown above the median line (see Fig. 23).

Biology.—These are not known at the present time.

Habits.—This species is nocturnal and thamnophilous and probably carnivorous as well as phyllophagous.

Song.—The song of *P. grandis* is not known.

Host Plant.—In the canyon just west of Cuidad Victoria, Tamaulipas, the writer took two females, one in *Karwinskia humboltiana,* the other in *Acacia wrightii.*

Records.—Canyon 3 miles west of Ciudad Victoria, Tamaulipas, Mexico, August 31, 1940, 3 ♀ (E. R. Tinkham). The type locality is Alta Mira, Tamaulipas, Mexico. Caudell reported specimens from Carrizo Springs and Eagle Pass and Brownsville.

Texas and Montelovey, Mexico. Hebard, in 1932, reported a female from Rodriguez, Nuevo Leon, Mexico.

Distribution.—Pediodectes grandis is a member of the Tamaulipan Semi-Desert Bushland and is known from Ciudad Victoria in Tamaulipas north to Corrizo Springs, Texas, and from the east base of the Sierra Madres Oriental to the Gulf coast.

PEDIODECTES BRUNERI (Caudell)

1907. *Stipator bruneri* Caudell. Proc. U. S. Nat. Mus., **32**:343.

Coloration.—P. bruneri is a small species of dark brownish coloration and jet black lining the posterior margin of the lateral lobes of the pronotum which is enlarged to a spot at the humeral angles. The species can be quickly identified by the black face and the triangular patch of white covering the front of the face (see Fig. 24).

Biology.—The life history of *bruneri* is unstudied but it is believed that the nymphs appear in the early spring and become adults in August or early September. The female lays 42 ova.

Habits.—This species is campestrian, living amongst grasses on the mountain sides. The specimens are quite active during the day and jump into bushes where they hide to escape detection. The species is probably herbivorous but in captivity takes readily to grasshoppers offered to it, hence they are probably carnivorous as well.

Song.—The song of *P. bruneri* is not known.

Food Plants.—As this species is found chiefly in grasses it may feed on grasses and other vegetation, but it is also likely that being partly carnivorous it catches grasshoppers and other insects which serve as food.

Records.—Davis Mts., Prudes Ranch, elev. c. 6000 feet, Oct. 6, 1929, 1 ♂; Davis Mts., south slope of Mt. Livermore, elev. c. 7800 feet in tall grasses, Sept. 29, 1931, 5 ♂, 6 ♀; Twenty miles west of Ozona, Texas, Sept. 13, 1940, 2 ♀ (E. R. Tinkham). The Type Locality is Belfrage, Texas, and Caudell reported a female from Quanan, Texas.

Distribution. — In southwestern Texas this species is found in Upper Sonoran Zone of the Pines and Oaks of the higher Mountains and occasionally is taken in the upper limits of the Lower Sonoran zone in semi-desert environment. *P. bruneri* is known from Quanah, in northern Texas south to Belfrage and west through the Edwards Plateau to the Davis Mountains of the Big Bend Region of Trans-Pecos Texas.

PEDIODECTES TINKHAMI Hebard

1934. *Pediodectes tinkhami* Hebard. Trans. Amer. Ent. Soc., **60**:35, Pl. 2, fig. 1; Pl. 3, figs. 1, 2.

Coloration.—This interesting species is quickly recognized from all other Desert Decticids by the broad arcuate band of bright cream color, crossing

the face just below the eyes and extending from the posterior margin of the head to the opposite posterior margin in a gently decurved band about one-sixteenth of an inch in width. The legs, especially the caudal ones are tinged with green. The general color is cinnamon buff mottled with clay color and microscopic streaks of tawny olive.

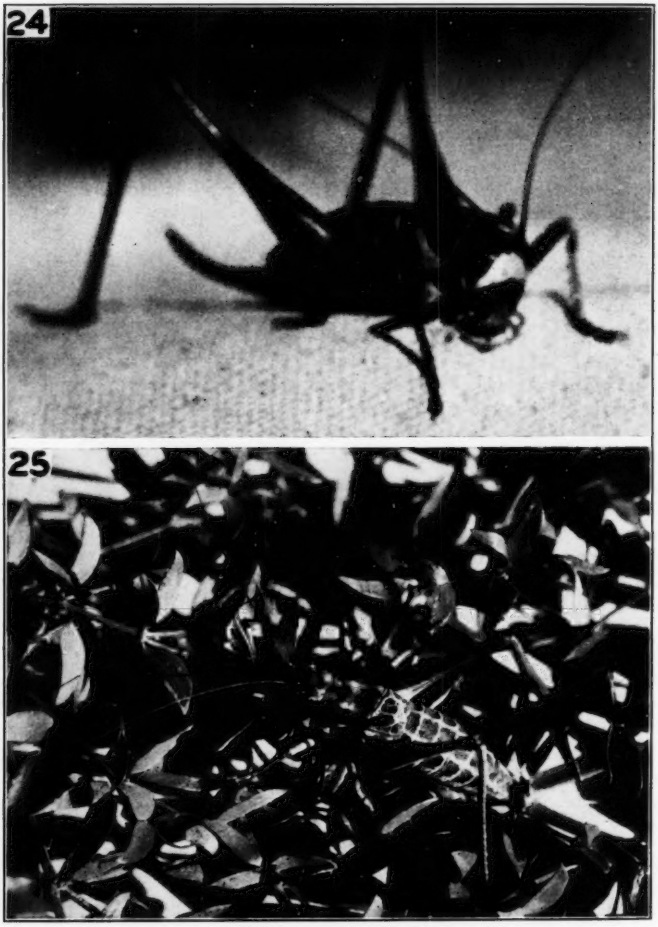


Fig. 24. Showing white-banded face of *Pediodectes bruneri* (2 × nat. size).

Fig. 25. Showing male *Eremopedes scudderi* (1-¼ × nat. size) in host plant *Larrea divaricata*.

Biology.—The eggs hatch in the spring and the nymphs become adults in August as I have taken nymphs in July. Aside from this fact little is known about the life history of this strangely marked species.

Habits.—Specimens taken at the Wadi Burnum Ranch House at the north base of the Chisos mountains in mid-July, 1930, were taken from a fly-trap which was baited with sour dough. Remains of others, one or two of which were in good condition, were found in pools of water in a small stream at the Wilson Ranch on the north base of Mt. Emory, highest peak of the Chisos range. At first I had supposed that these specimens had met their death when caught by the sudden arroyos sweeping down the dry creek bed, for the first specimen I found had been found in a pool of water in Cibolo Arroyo, just above Shafter in the Chinati Mountains, after a storm, but on discovery of the Wilson Creek specimens I abandoned this idea as there had been no rain for weeks. It appears that these large crickets meet accidental death, probably at night, while seeking water or jumping around in search for food. This species has great saltatorial powers and appears to be terrestrial rather than thamnophilous like most other Decticids.

Song.—I have never heard a male of *P. tinkhami* singing.

Host Plant.—This species is probably carnivorous, perhaps also a scavanger feeding on bits of organic matter to be found on the desert. The adults become active about sundown.

Records.—The type male was captured by the writer on Sept. 29, 1928 on a limestone hillside in the Chinati Mountains some four miles south of Shafter, Presidio County, Texas, vegetated with Ocotillo, *Fouquieria splendens*, Spanish Dagger *Agave lechuguilla*, Huisache *Acacia farnesiana* and other desert plants. The female type came from the Wadi Burnum Ranch, at the north base of the Chisos Mountains of Brewster County, Texas. Paratypes came from the Wadi Burnum Ranch and from the Ord Mountains collected by the field naturalist Mr. O. C. Poling. The writer has a female nymph taken July 3, 1930, at the San Carlos Mines, 10 miles south of San Carlos, Chihuahua, Mexico. This is the first Mexican record.

Distribution.—*Pediodectes tinkhami* is a member of the Lower Sonoran Fauna restricted to the desert mountains, chiefly of limestone, of the Chihuahuan Desert.

PEDIODECTES ATELOPLOIDES (Caudell)

1907. *Stipator ateloploides* Caudell. Proc. U. S. Nat. Mus., **32**:350.

1932. "*Stipator*" *ateloploides* Hebrad. Trans. Amer. Ent. Soc., **58**:338.

1934. *Pediodectes ateloploides* Hebard. Trans. Amer. Ent. Soc., **60**:36.

This interesting and rare species is known only from the unique female type described San José del Cabo, Baja California. It is distinguished by the very narrow vertex and other features resembling the genus *Ateloplus*. The discovery of the male is awaited with interest as it is needed to decide the generic placement of this species. Nothing is known concerning the biology, habits, song or food plants of this rare species.

EREMOPEDES Cockerell

1894. *Eremopedes* Scudder. Can. Ent., **26**:178, 181 (invalid).
1897. *Eremopedes* Scudder. Guide Orth. N. Am., p. 56 (invalid).
1898. *Eremopedes* Cockerell. Ann. Mag. Nat. Hist. **2**(7):323.
1900. *Eremopedes* Scudder. Cat. Orth. U. S., pp. 78, 97.
1902. *Eremopedes* Scudder. Proc. Davenp. Acad. Nat. Sci., **9**:55.
1902. *Eremopedes* Caudell. Can. Ent., **33**:100.
1906. *Eremopedes* Kirby. Syn. Cat. Orth., **2**:192.
1907. *Eremopedes* Caudell. Proc. U. S. Nat. Mus., **32**:330.

Species of this genus are small to medium in size and of a grayish or greenish coloration and often with dorso-lateral pale markings. From *Ateloplus, Eremopedes* is distinguished by the more slender build, slightly longer and narrower pronotum with deeper lateral lobes. The cerci in the *scudderi* group including *bilineatus* and *covilleae* are long and slender with a large median internal tooth prong; in *balli* and *ephippiatus* the cerci are broad and short with an inner apical tooth or series of fine teeth and these are closely similar in form to *Ateloplus schwarzi* and *A. minor;* these two genera show closest affiliation through these species. From *Pediodectes* on the other hand, *Eremopedes* exhibits much slenderer build, shorter caudal femora, and the prosternum which is usually unarmed or sometimes weakly spined, is strongly spined in *Pediodectes*. In *Eremopedes* the tegmina are exposed for about half the length of the pronotum and in *Pediodectes* is much less exposed; sexes of both genera in the females have the tegmina covered by the pronotum.

Eremopedes is further characterized by the spination of the legs. The fore and middle femora are unarmed; the caudal femora usually unarmed but in some species with about 6 outer and inner small black spines on the lower keels. Fore tibiae with 6 pairs of ventral teeth and 2 outer dorsal teeth; meso-tibiae with 6 pairs of ventral teeth and 2 outer and 4 inner dorsal teeth; caudal tibiae with approximately 26 pairs of dorsal spines on both inner and outer keels and some 6 to 9 outer and inner widely spaced teeth on the ventral side. Ovipositor as long as the caudal femora or distinctly shorter; with a slight recurvature.

Genotype.—Eremopedes scudderi Cockerell.

KEY TO THE SPECIES OF EREMOPEDES

1. Cerci long and slender, slightly outcurved in apical half bearing a median or subapical inner toothed prong. Outer pagina of caudal femora not striped with black. Humeral angle of pronotum not shining black 2
Cerci short and broad with the inner apex toothed. Outer pagina of caudal femora with two basal black stripes. Humeral angles of the pronotum marked with shining black. Color dark brown 5

2. Color green, form slender with a pair of white dorso-lateral stripes. Cerci long and internal tooth basad of center ..... *bilineatus*
Cerci with the internal tooth median or caudad of center. Form not as slender and without distinct dorso-lateral stripes 3

3. Male ultimate tergite with a deep narrow cleft reaching almost to the base of tergite. Tegmina black with veins white; posterior margin of pronotum buff.... *covilleae*

Male ultimate tergite with a "U" shaped emargination of varying depth produced by the length of the triangular processes of the tergite. Tegmina reddish brown or blackish brown, never black, with straw-colored veins 4

4. "U"-shaped emargination of ultimate tergite broad and shallow with the triangular lobes short and broad. Size very small. Portions of cercus beyond the internal tooth short ..... *shrevei* n.sp.

"U"-shaped emargination of the ultimate tergite deep with the triangulate processes narrow and long. Size large. Portion of the cercus beyond the internal tooth longer ..... *scudderi*

5. Tegmina and veins black with the outer margin of the tegmina edged with buff. Size small to large ..... *ephippiatus*

Tegmina black with veins and outer margin buffish. Size small ..... *balli*

EREMOPEDES SCUDDERI Cockerell

1898. *Eremopedes scudderi* Cockerell. Ann. Mag. Nat. Hist., **2**(7):323.
1898. *Eremopedes scudderi* var. *viridis* Scudder. ditto, p. 324.
1900. *Eremopedes scudderi* Scudder. Cat. Orth. U. S., p. 78.
1900. *Eremopedes scudderi* var. *viridis* Scudder. ditto, p. 78.
1901. *Eremopedes scudderi* Caudell. Can. Ent., **33**:19.
1901. *Eremopedes scudderi* var. *viridis* Caudell. ditto, p. 101.
1902. *Eremopedes scudder* var. *bicolor* Scudder and Cockerell. Proc. Davenp. Acad. Sci., **9**:54.
1906. *Eremopedes scudderi* Kirby. Syn. Cat. Orth., **2**:192.
1906. *Eremopedes scudderi* var. *viridis* Kirby. ditto.
1906. *Eremopedes scudderi* var. *bicolor* Kirby. ditto.
1902. *Eremopedes popeana* Scudder and Cockerell. Proc. Davenport. Acad. Sci., **9**:54.
1906. *Eremopedes popeana* Kirby. Syn. Cat. Orth., **2**:192.
1907. *Erempedes scudderi* Caudell. Proc. U. S. Nat. Mus., **32**:333, fig. 37.
1909. *Ateloplus macroscelus* Rehn and Hebard. Proc. Acad. Nat. Sci. Phila., p. 169, fig. 17 (♀:El Paso, Texas).
1929. *Eremopedes scudderi* Hebard. Proc. Acad. Nat. Sci. Phila., p. 403 (Colo.).
1935. *Eremopedes scudderi* Hebard. Proc. Acad. Nat. Sci. Phila., p. 75 (New Mexico).

Synonymy.—Caudell in 1907 placed the varieties *viridis* and *bicolor* and the species *popeana* as synonyms. Hebard, in 1929, placed *Ateloplus macroscelus* in synonymy.

Coloration.—Two color phases of this interesting species are found, a green and a gray phase. Great variation is found in both color forms, both having uniform colored specimens and others which are broadly banded with whitish or buff down the dorsum of the body. Still others may show intergrading colors with faint indications or dorso-lateral stripes of pinkish coloration on the abdomen as shown in the specimen in Fig. 25.

Biology.—The eggs hatch in the spring and the nymphs become adults in July or August; the males arriving at the adult stage first. The female lays or deposits in the ground her 24 pearly gray eggs in the fall of the year. The ova measure 4.75 mms. long by 1.35 mms. broad.

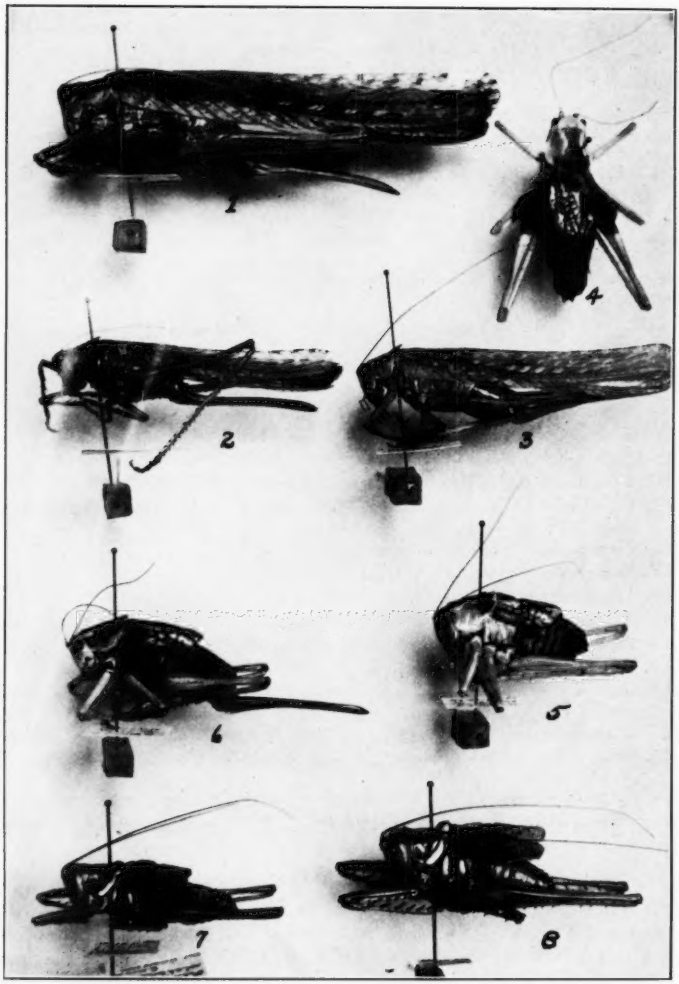


Fig. 26. Showing Capnobotes, Zycloptera, Rehnia: 1. Male *Capnobotes fuliginosus;* 2. Female *Capnobotes occidentalis* gray phase; 3. Female *Capnobotes occidentalis* green phase; 4, 5. Males of *Zycloptera atripennis;* 6. Female of *Zycloptera atripennis;* 7. Male of *Rehnia victoriae;* 8. Male of *Rehnia cerberus.* All figures about two-thirds natural size.

Habits.—This species is nocturnal and thamnophilous and phyllophagous. Adults, however, are found sunning themselves in the early morning hours amongst the leaves of their host plant. This species exhibits cannibalistic traits when several are confined together but in nature they are probably only partially cannibalistic, and only on other insects.

Song.—The song of *E. scudderi* is a soft low "zeeee-e — zeeee-e — zeee-e — zeee-e — zeee-e — zeee-e" that is continuous for a long period but cannot be heard at distances greater than fifteen feet.

Host Plants.—In southern Coahuila the writer found this species chiefly in Creosote *Larrea divaricata.* In the Davis Mts., the host plant is *Acacia constricta;* in northeastern Arizona this species was hiding in clumps of ground Yucca *Yucca elata.* The host varies with the locality. Hebard (1935) reports it from *Sarcobatus vermiculatus* in northern New Mexico.

Records.—Texas: Chinati Mts., Presidio Co., July 8, 1929, 1 ♀ in flower stalk of *Dasylirion texanum;* Sept. 16, 1929, 1 ♂ in clump of *Agave lechuguilla;* Sept. 20, 1931, 1 ♂ singing in *Opuntia arborescens.* Paisano July 22, 1930, 1 ♂ juv. North base Chisos Mts., Brewster Co., July 18, 1930, 1 ♀; Twenty miles north Chisos Mts., July 18, 1930, 1 ♂ in *Larrea.* North end Davis Mts., 6 miles Sw. Toyahvale, Sept. 13, 1940, 2 ♂. Mulligan Canyon near El Paso, Sept. 16, 1931, 3 ♂, 1 ♀. All taken by E. R. Tinkham. New Mexico: Reported from Pojoaque, Rio en Medio and Rancho del Monte by Hebard, in 1935. The type locality is Mesilla Park near Las Cruces. Arizona: Four Miles East of Concho, July 16, 1940, 1 ♂, 2 ♀ juvs., this is the first record for Arizona. Taken by E. R. Tinkham. Coahuila: 42 miles northwest Saltillo, Sept. 3, 1940, 2 ♂, 1 ♀; 6 miles north Parras, Sept. 4, 1940, 1 ♂; Sierra de Parras, 4 miles south of Parras, Sept. 5, 1940, 1 ♀ in *larrea divaricata* (E. R. Tinkham). Chihuahua: Reported from Jaral by Hebard, in 1932.

Distribution.—E. scudderi is a member of the Lower Sonoran Faunal region and is restricted to the Chihuahuan Desert.

EREMOPEDES COVILLEAE Hebard

1934. *Eremopedes covileae* Hebard. Trans. Amer. Ent. Soc., **60**:39, Pl. 2, fig. 2; Pl. 3, Fig. 3.

Coloration.—This handsome katydid is quickly recognized by its uniform green coloration with the posterior margin of the pronotum edged with buff; the black tegmina with the veins whitish and by the deeply cleft ultimate tergite of the abdomen.

Biology.—This species emerges from the eggs in the early spring and the males mature in mid-July and the females a little later.

Habits.—E. covilleae appears to be thamnophilous, nocturnal and strictly phyllophagous. Adults sun, however, during the day on their favorite host plant.

Song.—The song of this katydid is not known.

Host Plant.—As far as is known this species is restricted to the Creosote Bush *Larrea divaricata.*

Records.—The only specimens known are the Type specimens taken by the writer on

July 18, 1930, on the Creosote desert, twenty miles north of the Chisos Mountains of Brewster County, Texas, on the Marathon-Boquillas Road.

Distribution.—*E. covilleae* is a member of the Lower Sonoran Faunal region restricted to the Chihuahuan Desert.

EREMOPEDES BILINEATUS (Thomas)

1875. *Steiroxys bilineatus* Thomas. Rept. Expl. and Surv. West of 100th Mer., **5**:950 (♀: San Carlos, Arizona).
1894. *Idiostatus bilineatus* Scudder. Can. Ent., **26**:181, 183.
1899. *Cacopteris sinuata* Scudder. Proc. Amer. Acad. Arts Sci., **35**:88, 90.
1900. *Cacopteris sinuata* Scudder. Cat. Orth. U. S., p. 78.
1900. *Idiostatus bilineatus* Scudder. Cat. Orth. U. S., p. 78.
1902. *Plagiostira albofasciata* Scudder and Cockerell. Proc. Davenp. Acad. Nat. Sci., **9**:55, Pl. 3, fig. 2 (♀: Mesilla Jk., N. Mex.).
1905. *Plagiostira gracila* Rehn. Publ. Kans. Acad. Sci., p. 227.
1906. *Idiostatus bilineatus* Kirby. Syn. Cat. Orth., **2**:194.
1906. *Idiostatus sinuata* Kirby. Syn. Cat. Orth., **2**:193.
1906. *Plagiostira albofasciata* Kirby. Syn. Cat. Orth., **2**:195.
1907. *Eremopedes albofasciata* Caudell. Proc. U. S. Nat. Mus., **23**:337, fig. 40.
1907. *Idiostatus sinuata* Caudell. Proc. U. S. Nat. Mus., **32**:379, figs. 64, 65.
1909. *Eremopedes albofasciata* Rehn and Hebard. Proc. Acad. Nat. Sci. Phila., p. 169.
1909. *Eremopedes gracilis* Rehn and Hebard. Proc. Acad. Nat. Sci. Phila., p. 480.
1935. *Eremopedes bilineatus* Hebard. Trans. Amer. Ent. Soc., **61**:311 (synonymy).

Synonymy. — Hebard, in 1935, synonymized *Cacopteris sinuata* Sc., *Plagiostira albofasciata* Sc. and Cock., and *P. gracila* Rehn.

Coloration.—The general coloration in this rather slender species is foliage green with dorso-lateral stripes of white. Much variation exists in locality-specimens. Specimens from Yuma are very large with a very wide band, this band gradually diminishing in width as one progresses east across Arizona and in New Mexico specimens the dorso-lateral stripe is practically evanescent. As one goes north into the Mojave Desert the size decreases rapidly, specimens from Beatty, Nevada, being less than one-half the size of Yuma specimens.

Biology.—The eggs are laid in the fall and hatch in the spring, the adults appearing in July and August during the rainy season.

Habits.—This species is thamnophilous, nocturnal and strictly phyllophagous on its host plant.

Song.—The song of *E. bilineatus* is a rapid and rather low "tzee — tzee — tzee-tzee-tzee" produced for long periods of time. Specimens from various localities often sound differently sometimes like "sitz-sitz-sitz-sitz" or variations of these notes.

Host Plant.—The chief host plant of this species is *Larrea divaricata* with *Baccharis sarrathroides,* Desert Broom second in importance.

Records.—In 1931, the writer and his brother, Herb, took large series of this species in the following mountain ranges in Arizona: Gilas; Mohawks; Gila Bend; Maricopas;

Saucedos; Ajos; Quoatoas; Cobabis; Quinlans; Tucsons; Santa Ritas. One male was taken near Cambray, New Mexico. All these specimens are in the Hebard Collection in Philadelphia. The writer has taken additional specimens at many other localities in southeastern Arizona. One dwarf male was taken Oct. 20, 1939, six miles south of Beatty, Nevada, which is the northwestern most limit in the distribution of this species.

Distribution.—*E. bilineatus* is a member of the Lower Sonoran Faunal Region having a wide distribution on the Sonoran Desert ranging northwest, where it becomes very small in size, over the Mojave Desert to the northern limits of that Desert as marked by the distribution of *Larrea divaricata*. Its eastern limits are the Rio Grande valley in southern New Mexico.

Eremopedes shrevei n. sp.

E. shrevei n. sp. is a member of the *scudderi* group distinguished by its very small size, shallow "U"-shaped median groove of the ultimate tergite of the male and with the processes of this tergite short and broadly triangular and cerci slightly shorter than in *scudderi*. Nearest relationship is shown to *E. scudderi*.

Type.—♂, 16 miles north of Doctor Arroyo, southern Nuevo Leon, Mexico, Aug. 25, 1940 (E. R. Tinkham; in mesquite). Measurements in millimeters: body length 14.5; pronotum 5.8 x 4.5 broad exposed tegmina 2.0; caudal femora 15.0 x 3.0 mms. Type in the Tinkham Collection.

Description.—Form typical for the genus. Pronotum uniformly broad throughout, decidedly broader than in *scudderi* specimens of very small and of equal size; caudal femora definitely heavier than in *scudderi* specimens of equal size. All femora unarmed; fore tibiae with 6 pairs ventral teeth and 3 dorsal teeth. Meso-tibiae with 6 pairs ventral and 2 outer and 3 to 4 inner dorsal teeth; caudal tibiae with 24-25 pairs of dorsal spines and 7 outer and inner small widely spaced ventral teeth. Male ultimate tergite with a shallow "U"-shaped groove with short and broad paired triangular processes. Cerci shorter than in *scudderi* with the internal tooth slightly caudad of center. Apex of the subgenital plate with a shallow concave excision. All the thoracic sternites unarmed.

Coloration.—Color uniformly dark stone gray with the tegmina dark brownish at the base and the outer and exposed half testaceous.

Biology.—These are not known at this time.

Habits.—This small species is thamnophilous and nocturnal.

Song.—The song of this new species is a soft low "zee — zee — zee — zee — zee" continuous and inaudible beyond a few feet.

Distribution.—*Eremopedes shrevei* n. sp. is restricted to the Desert of Salado, the southern sub-type of the Chihuahuan Desert.

This species is named in honor of Dr. Forrest Shreve, leader of the Shreve-Tinkham Expedition into northeastern Mexico, in August and September of 1940.

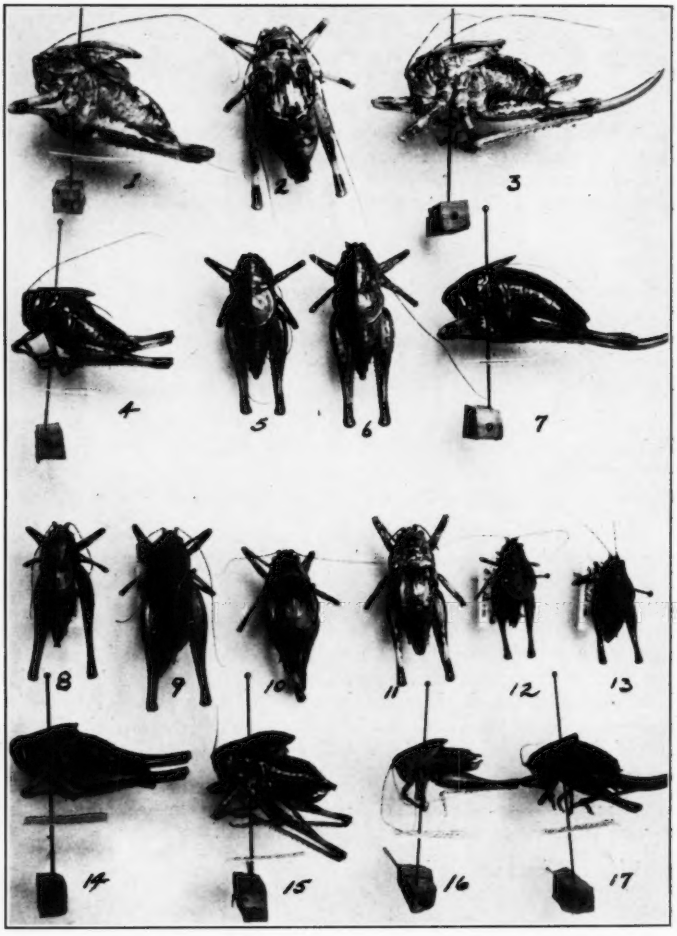


Fig. 27. Showing the following species: 1-2. *Aglaothorax segnis* two males, Sierra Nevadas; 3. *Aglaothorax segnis* female; 4-5. *Neduba carinata* males from Sierra Nevadas; 6. *Neduba convexa* male from Walker Pass; 7. *Neduba carinata* female from Sierra Nevadas; 8. *Neduba sierranus* male from Yosemite; 9. *Neduba diabolica* from Tehachapis; 10. *Aglaothorax ovatus* male, San Gabriel Mts.; 11. *Aglaothorax armiger* male from southern Nevada; 12-13. *Neduba morsei* two color phases, San Gabriels; 14. *Neduba diabolica* male, lateral view; 15. *Aglaothorax ovatus* male lateral view; 16. *Neduba morsei* male lateral view; 17. *Neduba morsei* female, lateral view. All figures about two-thirds natural size.

EREMOPEDES BALLI Caudell

1901. *Eremopedes balli* Caudell. Can. Ent., **33**:100 (part).
1903. *Eremopedes balli* Caudell. Proc. U. S. Nat. Mus., **26**:807.
1906. *Eremopedes balli* Kirby. Syn. Cat. Orth., **2**:192.
1907. *Eremopedes balli* Caudell. Proc. U. S. Nat. Mus., **32**:335, fig. 38.
1935. *Eremopedes balli* Hebard. Trans. Amer. Ent. Soc., **61**:311.

Coloration.—This, one of the smallest species in the genus, is recognized by its dark brown coloration, the pronotum is often yellowish brown, and the two black stripes on the outer pagina or face of the caudal femora. The humeral angles of the pronotum are marked with black and the tegmina are black with the veins buffish, this latter feature and the slightly different form of the cerci separating *balli* from *ephippiatus*.

Biology.—The eggs of this mountain dwelling species are laid in the fall and the young, appearing in the spring, mature in July and August. This species is often found dwelling in clumps of brachen fern on the tops of high mountains such as the Santa Catalinas. The species hides in amongst the plants and grasses during the day.

Habits. — This small species is campestrian living amongst ferns and grasses and is active by day whenever disturbed. The species is probably strictly vegetarian.

Song.—The song is a soft low "zee-zee-zee-zee-zee" continuous and quite typical of *Eremopedes*.

Records.—Magdalena Mts., New Mexico, elev. 9600 feet, July 23, 1930, 1 ♂; Santa Catalina Mts., Arizona, elev. 9100 feet, Oct. 22, 1938, 3 ♀, (E. R. Tinkham). Santa Catalinas, elev. 9100 feet, Sept. 5-6, 1931, 5 ♂, 2 ♀; north end Quinlan mts., Sept. 3, 1931, 1 ♂ (E. R. Tinkham; Hebard Cln.). The types came from Williams and Flagstaff, Arizona, but were confused in the original description with *Pediodectes stevensoni* from Ft. Collins, Colorado.

Distribution.—*E. balli* is a member of the Pine Zone and is found at high elevations in the mountains of southern Arizona, such as the Quinlan, Baboquivaris, Santa Ritas and Santa Catalinas and in northern Arizona is found on the Mogollon Plateau which extends east into the heart of New Mexico.

Eremopedes balli pallidus n. subsp.

Specimens of *E. balli* from the Petrified Forest of Arizona represent a race confined to the Painted Desert which in reality is the southeastern corner of the Great Basin Desert. This species is characterized by its slightly larger size, pale and uniform light brown coloration, and the lack of the two black stripes on the outer surface of the caudal femora.

Type — ♂, Petrified Forest, Arizona, July 16, 1940 (Park Naturalist Smith). Measurements in millimeters: body length 20.0; pronotum 7.0 x 4.3; exposed tegmina 2.0; caudal femora 18.0 mms.

Allotype.—♀, same data as the type. Measurements in millimeters: body length 20.0; pronotum 6.3 x 4.0; caudal femora 20.4 x 4.0 max. breadth; ovipositor 16.0 mms. One female paratype same data as the allotype. Types in the Tinkham collection.

EREMOPEDES EPHIPPIATUS EPHIPPIATUS (Scudder)

1899. *Cacopteris ephippiata* Scudder. Proc. Amer. Acad. Arts Sci., **35**:88-91.
1900. *Eremopedes unicolor* Scudder. Cat. Orth. U. S., p. 97.
1901. *Eremopedes unicolor* Caudell. Can. Ent., **33**:99.
1903. *Eremopedes unicolor* Caudell. Proc. U. S. Nat. Mus., **26**:807.
1906. *Cacopteris ephippiata* Kirby. Syn. Cat. Orth., **2**:193.
1906. *Cacopteris unicolor* Kirby. Syn. Cat. Orth., **2**:193.
1907. *Eremopedes ephippiatus* Caudell. Proc. U. S. Nat. Mus., **32**:332, figs. 35-36.
1909. *Eremopedes unicolor* Rehn and Hebard. Proc. Acad. Nat. Sci. Phila., p. 480.
1935. *Eremopedes ephippiatus* Hebard. Trans. Amer. Ent. Soc., **61**:311.

Coloration.—This species is slightly larger than *E. balli* and of a uniform reddish brown. The tegmina are solid black with the posterior margin edged with buffish, contrasting with the tegmina of *E. balli* which are black with the veins buffish. The cerci are broader than in *E. balli* with the outer margin slightly convex and not concave as in *balli*.

Biology.—The life history of this species is not known but like other species of the genus the nymph undoubtedly appear in the spring and the adults in mid-summer as specimens taken earlier than mid-July are usually nymphs.

Habits.—Like other species of the genus this species is nocturnal and either thamnophilous or sylvan, the writer has taken specimens in the Huachuca Mountains crawling over oak leaves on the forest floor.

Food Plants.—This species is probably phyllophagous as well as a scavenger feeding on bits of organic matter that it finds as it wanders about for food.

Song.—The song is characteristic of the genus.

Records.—Huachuca Mountains, Miller Canyon, Arizona, Sept. 4, 1938, 1 ♂; Oct. 22, 1938, 1 ♀; Carr Canyon, June 14, 1940, 1 ♂, (E. R. Tinkham). The type females was described from "Arizona" and the male type from Sonora, Mexico. Caudell reported specimens Hot Springs, Phoenix, Oracle, Douglas and the Huachuca Mountains.

Distribution.—This species appears to be a member of the Sonoran Live Oak Zone of southeastern Arizona.

Eremopedes ephippiatus sonorensis n. subsp.

1932. *Eremopedes ephippiata* Hebard. Trans. Amer. Ent. Soc., **58**:338 (Sonora, Mexico).

This subspecies closely resembles *E. ephippiatus ephippiatus* but is quickly recognized by the very large size, being almost twice the size of the nominal race, and of a very dark grayish black coloration. The prosternum is usually spined, five out of six males having bispinose prosternites.

This subspecies inhabits the more torrid areas of the Sonoran Desert characterized by the Ironwood (*Olneya tesota*) and the Resin Plant (*Encelia*

farinosa) Zone. This zone is found in southwestern Arizona and in Sonora, Mexico, south to the Yaqui River.

Type.—♂, Sonora, Mexico, 40 miles north of Hermosillo, Nov. 1, 1939 (E. R. Tinkham). Measurements in millimeters: body length, 28.0; pronotum 9.0 x 6.0 max. metazonal breadth; exposed tegmina 3.0; hind femora 32. 5 mms.

Paratypes.—5 ♂, same data as the type. Range in measurements in millimeters: body length 27.0-29.0; pronotum 9.0-9.5 x 5.6-6.0 broad; exposed tegmina 4.0-4.0; hind femora 35.5-36.5 mms. Type and Paratypes in the Tinkham Collection.

The song of this species is a strong "zee-zee-zee-zee" continuous and audible for fifty feet or more.

Distribution.—In 1932, Hebard recorded two females from the Copete Mines, thirty miles east of Carbo, Sonora. The University of Arizona Collection contains a series of males and females from the Baboquivari mountains, Arizona. *E. ephippiatus sonorensis* n. subsp. is a member of the Lower Sonoran Faunal Region and in distribution is restricted to the hotter southern portions of the Sonoran desert. It is known from Carbo and the desert forty miles north of Hermosillo, Sonora, north to the Baboquivari Mountains of south-central Arizona.

EREMOPEDES SPINOSA Hebard

1923. *Eremopedes spinosa* Hebard. Proc. Cal. Acad. Sci., (4), **12**:337, figs. 10-13.
1932. *Eremopedes spinosa* Hebard. Trans. Amer. Ent. Soc., **58**:339.

This species was described by Hebard from Mejia Island and Angel de la Guardia Island in the Gulf of California. No additional specimens have been taken and the life history, song, host plants and habits remain unknown.

IDIOSTATUS Pictet

1888. *Idiostatus* Pictet. Mem. Soc. Phys. Genev., **30**:63.
1894. *Idiostatus* Scudder. Can. Ent., **26**:178, 181.
1894. *Cacopteris* Scudder. Can. Ent., **26**:178, 181 (invalid).
1897. *Idiostatus* Scudder. Guide N. Amer. Orth., p. 56.
1897. *Cacopteris* Scudder. Guide N. Amer. Orth., p. 56 (invalid).
1899. *Cacopteris* Scudder. Proc. Amer. Acad. Arts Sci., **35**:87.
1900. *Idiostatus* Scudder. Cat. Orth. U. S., p. 78.
1900. *Cacopteris* Scudder. Cat. Orth. U. S., p. 78.
1906. *Idiostatus* Kirby. Syn. Cat. Orth., **2**:193.
1906. *Idiostatus* Kirby. Syn. Cat. Orth., **2**:194.
1907. *Idiostatus* Caudell. Proc. U. S. Nat. Mus., **32**:373.
1920. *Idiostatus* Rehn and Hebard. Trans. Amer. Ent. Soc., **46**:254.
1934. *Idiostatus* Hebard. Trans. Amer. Ent. Soc., **60**:45.

Members of the genus range from small to medium size and are usually grayish or greenish in coloration with a few of the species characterized by the male ultimate tergite being shining black. The tegmina is usually a pale reddish brown color. The fore and middle femora are either unarmed or armed with a few small black spines on the inner keel of the fore femora or outer keel of the meso-femora; caudal femora unarmed or with from 1 to 10 small spines on both outer and inner lower keels. Fore tibiae with 6 pairs of long ventral teeth and 3 outer dorsal ones; meso-tibiae with 6 pairs of long ventral teeth and 2 to 3 outer and 4 inner dorsal teeth; caudal tibiae with two full spine rows on the dorsal keels and from 6 to 10 outer and 4 to 6 inner very small ventral teeth. Ovipositor gently recurved and of various length as long as or shorter than the caudal femora.

Genotype.—Idiostatus californicus Pictet (=*hermanii* Thomas). Fourteen species of *Idiostatus* are known, five of which have been described in the last decade. Of this number eight species are found east of the Sierra Nevadas and six species west of that lofty range of mountains. The six species restricted to the Californian coastal regions west of the Sierra Nevadas are: *I. rehni* Caudell, *I. hermanii* (Thomas), *I. fuscus* Caudell 1934, *I. wymorei* Caudell 1934, *I. aequalis* Scudder 1899, and *I. inermis* var. *major* Caudell 1934. These six will not be discussed.

KEY TO THE MALES OF NEARCTIC SPECIES OF IDIOSTATUS

1. Tegmina with a black mark in the apex; internal apical tooth lengthily directed caudad and incurved. 2
   Tegmina concolorous; internal apical tooth not directed lengthily caudad 3

2. Subgenital and supra-anal plates approximate in length, the latter with a broad median "U"-shaped groove ..... *aequalis*
   Subgenital plate projecting caudad of the supra-anal plate; the latter with a "V"-shaped median groove ..... *nevadensis*

3. Apex of male abdomen marked with shining black 4
   Apex of male abdomen not marked with shining black 7

4. Cerci with two long strongly uncinate teeth, the apical one long and attenuate and pointing downwards and inwards; inner subapical one uncinate and above the apical one ..... *inermis*
   Cerci with only small internal tooth 5

5. Size very large; internal tooth basal, apex of the cercus pointed ..... *elegans*
   Size large; internal tooth apical, apex of cercus transverse with a slight outer apical prominence ..... *magnificus*

6. Cerci large and very broad with a small median internal dentate prominence. Size very large and uniformly green ..... *hermanii*
   Cerci smaller and narrower. Size small to large, color usually grayish, rarely green 7

7. Internal apical tooth very long and slightly incurved, the tooth almost the length of the cercus ..... *hendersoni*
   Internal tooth much shorter than the length of cercus 8

8. Size small, outer margin of cercus convex and bearing a subapical tooth ..... *invo*
   Size small to large, outer margin of cercus almost straight 9

9. Internal cercal tooth acutely pointed 10
   Internal cercal tooth bluntly rounded ..... *fuscus*

10. Internal tooth subapical and uncinate, apex of cercus elliptical ..... *wymorei*
Internal tooth apical, apex of cercus obliquely truncate 11

11. Inner margin of cercus right-angularly bent at internal tooth ..... *rehni*
Inner margin of cercus gently concave to apex of the internal tooth..... *variegatus*

IDIOSTATUS MAGNIFICUS Hebard

1934. *Idiostatus magnificus* Hebard. Trans. Amer. Ent. Soc., **60**:46, Pl. 2, fig. 4; Pl. 3, fig. 6.

This large and beautifully marked species is known from the unique type male taken on Cedar Peak, Warner Mountains, Modoc County, in the northeastern corner of California at an elevation of 8200 feet. The type was taken by Mr. James A. G. Rehn on August 25, 1922. Nothing is known concerning the biology of this species.

IDIOSTATUS ELEGANS Caudell

1907. *Idiostatus elegans* Caudell. Proc. U. S. Nat. Mus., **32**:384, fig. 71, 72.

This large species is recognized by the black on the posterior segments of the abdomen and by the short and rather heavy cercus with an internal basal tooth. The types, a single male and female were described from Nevada. No other information is available for this very large species.

IDIOSTATUS CALLIMERA Rehn and Hebard

1920. *Idiostatus callimera* Rehn and Hebard. Trans. Amer. Ent. Soc., **46**:255.

This interesting species of moderate size is quickly recognized by the proximal and median dark markings of the caudal femora. The species was described from Nevada. The habits and life history of this species are not known.

IDIOSTATUS INERMIS (Scudder)

1899. *Cacopteris inermis* Scudder. Proc. Amer. Acad. Arts Sci., **35**:88, 89.
1900. *Cacopteris inermis* Scudder. Cat. Orth. U. S., p. 78.
1906. *Cacopteris inermis* Kirby. Syn. Cat. Orth., **2**:194.
1907. *Idiostatus inermis* Caudell. Proc. U. S. Nat. Mus., **32**:386, fig. 73.

Coloration.—*I. inermis* is a small species, pale greenish in color with a pale reddish brown tint to the dorsum of the body, which are strikingly marked with black on the last abdominal segment. The tegmina are pale reddish brown and the cerci are very distinctive with apical and subapical long uncinate hooks.

Biology.—The life history of this species is not known but the evidence would indicate that the eggs hatch in the spring and the adults appear in midsummer.

Habits.—This pretty small species is nocturnal and thamnophilous, dwelling in sagebrush and it is without doubt strictly phyllophagous on the leaves of its host plant.

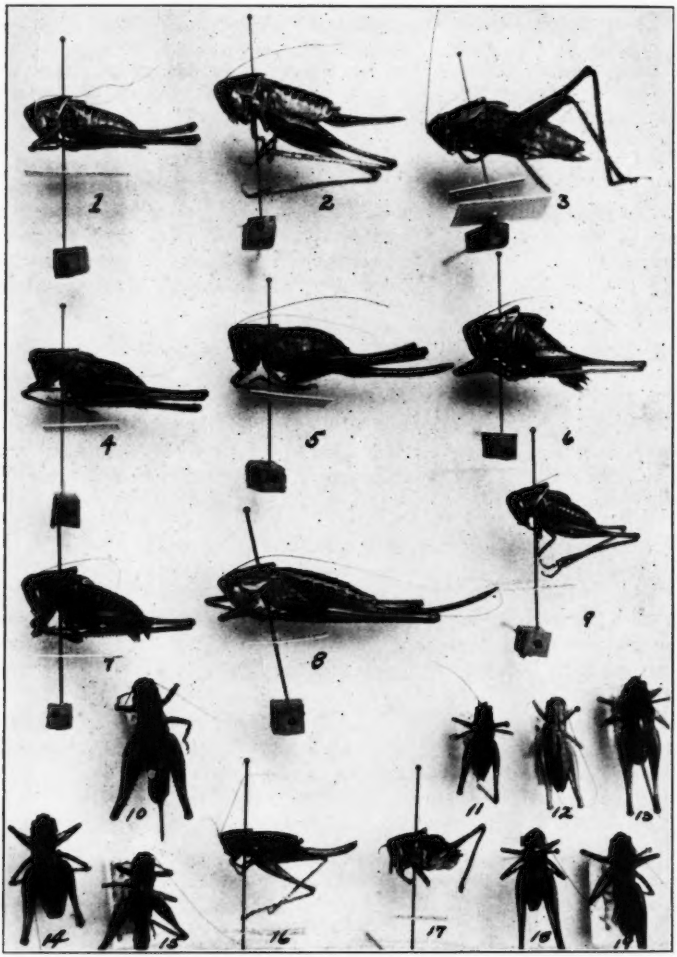


Fig. 28. Showing the following species: 1-2. *Clinopleura melanopleura* male and female; 3. *Ateloplus splendidus* male; 4-5. *Idionotus tehachapi* male and female; 6. *Idiostatus hermanii* male from Mt. Shasta; 7. *Idiostatus callimerus* male; 8. *Eremopedes bilineatus* male; 9. *Idiostatus inermis* male from Mono Lake; 10. *Ateloplus notatus* female; 11. *Ateloplus hesperus* topotype male; 12. *Ateloplus luteus* male; 13. *Idiostatus inermis* male from Mono Lake. 14. *Idiostatus inyo* large male from Walker Pass; 15. *Ateloplus notatus* male; 16. *Ateloplus hesperus* topotype female; 17. *Idiostatus wymorei* teneral male; 18. *Idiostatus inyo* from Lone Pine Canyon; 19. *Idiostatus aequalis* male. All figures about two-thirds natural size.

Song.—The song is a soft low "zea — zea — zea — zea — zea" continuous and audible for only a few feet.

Food Plants.—This species was taken in Sagebrush *Artemisia tridentata* at Mono Lake, California.

Records.—Mono Lake, California, at mouth of Tioga Pass, Aug. 13, 1938, 2 ♂ (E. R. and G. E. Tinkham). This species was described from Nevada and Caudell records a male from Reno, Nevada.

Distribution.—Further material reported by Caudell, in 1934, shows that this species is known from western Nevada, southern Oregon and northern California. The Mono Lake specimens represent the southernmost point in the distribution of this species. *I. inermis* is a member of the Great Basin Desert.

IDIOSTATUS VARIEGATA Caudell

1907. *Idiostatus variegata* Caudell. Proc. U. S. Nat. Mus., **32**:387.

1939. *Idiostatus variegata* Hebard. Trans. Amer. Ent. Soc., **65**:173, Pl. 8, figs. 6, 8.

The type locality of this interesting and most northern member of the genus, is Pocatello, Idaho. The type was a unique female. The life history of this species is not known. The range of this large member of the genus is in southern Idaho on the northern edge of the Great Basin Desert.

IDIOSTATUS HENDERSONI Hebard

1939. *Idiostatus hendersoni* Hebard. Trans. Amer. Ent. Soc., **65**:173, Pl. 8, figs. 5 and 7.

This, the most recently described species of *Idiostatus*, is of medium large size and rather robust form and can quickly be recognized from all other species of this genus by the very long and needle-like inner cercal tooth which is almost as long as the length of the cercus itself. Like most other species of this genus nothing is given concerning the life history or habits of these rare creatures. The type locality is Leamington, Utah. The species inhabits the Great Salt Lake Valley region of the Great Basin Desert.

IDIOSTATUS NEVADENSIS Scudder

1899. *Cacopteris nevadensis* Scudder. Proc. Amer. Acad. Arts Sci. **35**:88, 91 (male only).

1900. *Cacopteris nevadensis* Scudder. Cat. Orth. U. S., p. 78.

1906. *Cacopteris nevadensis* Kirby. Syn. Cat. Orth., **2**:194.

1907. *Idiostatus nevadensis* Caudell. Proc. U. S. Nat. Mus., **32**:378, fig. 63.

1934. *Idiostatus nevadensis* Hebard. Trans. Amer. Ent. Soc., **60**:46.

Coloration.—This small species is very closely related to *I. aequalis* in size and form of cerci, but the supra-anal plate is much shorter than the subgenital plate and the male ultimate tergite bears a "V"-shaped and not "U"-shaped median groove. The male tegmina has the apex infuscated with blackish.

Biology.—The biology of this small species is not known.

Habits.—Like other species this form is nocturnal, thamnophilous and phyllophagous.

Song.—The song is a soft low continuous "zee-zee-zee-zee."

Host Plant.—The writer has found this species in *Artemisia tridentata* and in snake weed *Gutierrezia.*

Records.—Virginia City, Nevada, July 28-31, 1931, 6 ♂, 4 ♀; Two miles south of Gardnerville, Nevada, Aug. 1, 1931, 1 ♂ (E. R. and H. A. Tinkham; Hebard Cln.).

Distribution.—*I. nevadensis* is found in west central Nevada and is a member of the Great Basin Desert fauna.

IDIOSTATUS INYO Rehn and Hebard

1920. *Idiostatus inyo* Rehn and Hebard. Trans. Amer. Ent. Soc., **46**:254.

Coloration.—This small species is mottled gray in color with the tegmina uniformly pale reddish brown. The cercus is distinctive and incurved with a subapical internal tooth that separates this species readily from others of the genus.

Biology.—From field collecting this species unquestionably hatches in the spring and the adults appear in August as I have taken nymphs at that time.

Habits.—This species is nocturnal and thamnophilous and phyllophagous. On one occasion this species did not appear on the tops of its host plant until after midnight. What appeared at first to be a barren evening suddenly after midnight turned out very fruitful and a big catch was made.

Song.—The song of *I. inyo* is a very faint and low "zee-zee-zee-zee-zee-zee" continuous, and scarcely discernible at five feet distance.

Host Plants.—In Lone Pine Canyon the writer has taken this species on *Eriogonum* sp., and *Artemisia tridentata.* In Big Pine Canyon the females especially were very fond of, along with *Neduba carinata,* the small blue berries growing on a hollow-stemmed, *Rhus*-like plant growing to six or eight feet high. At the west base of the Montgomery Pass, a large series was taken in Russian thistle *Salsola pestifer,* which was young and green.

Records.—West base Montgomery Pass near California line, Aug. 15, 1938, 16 ♂, 20 ♀; Big Pine Canyon, Aug. 16, 1938, 3 ♂, 2 ♀; Lone Pine Canyon, Aug. 17, 1938, 8 ♂, 5 ♀; Walker Pass, Aug. 22, 1938, 1 ♂, 1 ♀ (E. R. and G. E. Tinkham).

Distribution.—*I. inyo* is known from Walker Pass at the south end of the Sierra Nevadas north in Owens Valley to the west base of Montgomery Pass. It is a member of the Mojave and Great Basin Deserts.

Summary and Conclusions

In this paper the floristic characteristics and geographical range of the various deserts are discussed first. This is followed by an account of the zoogeography of the Decticids and their host plant relationships and economic status and preservation. In the taxonomic and biological section a key to the

thirteen desert genera is presented together with a key to the various species of each genus. Each species is treated in regard to biology, habits, song, host plants and records, as far as information is available and each species is placed in its proper desert allocation. In all twelve genera and fifty-three species are treated, of which two are described as new, namely: *Rehnia pulchellus* and *Eremopedes shrevei*. Two new subspecies are also recognized, namely *Eremopedes balli pallidus* and *Eremopedes ephippiatus sonorensis*.

The following is a list of the species arranged according to the Desert Regions which they inhabit.

GREAT BASIN DESERT

Idiostatus nevadensis
Idiostatus callimera
Plagiostira albonotata
Plagiostira gilletti
Eremopedes balli pallidus n. subsp.
Zycloptera atripennis
Ateloplus luteus
Ateloplus hesperus
Idiostatus inyo
Idiostatus variegatus
Idiostatus hendersoni
Idiostatus elegans
Idiostatus inermis
Idiostatus magnificus
Aglaothorax segnis
Neduba carinata
Capnobotes fuliginosus

SONORAN DESERT

Mojave Desert

Ateloplus luteus
Aglaothorax armiger
Idiostatus inyo
Capnobotes occidentalis
Eremopedes bilineatus
Anoplodusa arizonensis
Aglaothorax segnis
Ateloplus coconino

Colorado Desert

Ateloplus notatus
Ateloplus splendidus
Eremopedes bilineatus

Sonoran Desert

Rehnia sinaloae
Ateloplus minor
Capnobotes fuliginosus
Eremopedes ephippiatus sonorensis n. subsp.
Eremopedes bilineatus
Ateloplus schwarzi
Anoplodusa arizonensis

CHIHUAHUAN DESERT

Rehnia cerberus
Pediodectes tinkhami
Pediodectes bruneri
Capnobotes fuliginosus
Eremopedes scudderi
Eremopedes covilleae

Salado Desert

Rehnia pulchellus n. sp.
Eremopedes shrevei n. sp.

LOWER CALIFORNIAN DESERT

Eremopedes spinosa
Pediodectes ateloploides

TAMAULIPAN SEMI-DESERT BUSHLAND

Rehnia spinosa
Rehnia victoriae
Pediodectes grandis

This paper presents one of the first discussions ever attempted to give the floristic characteristics of the various Deserts of North America supplemented by a map depicting the geographical distribution of the Deserts as recognized. It constitutes also the first attempt to treat the entire Shield-Back Katydid or Decticid Fauna of the North American Deserts and adjacent borders supplemented by biological notes accumulated through the years by the writer's own field investigations. Finally the Decticids are arranged according to their Desert distribution.

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Conspectus of the Genera of Pemphilidine Wasps (Hymenoptera: Sphecidae)

V. S. L. Pate

The Pemphilid wasps are clearly and definitely circumscribed, but there is today no complex of the Sphecoids, save perhaps the Gorytines, in which more confusion reigns or lack of agreement exists as to what constitutes valid and natural supraspecific categories. Since Fabricius in 1775 first recognized the group as distinct under the name *Crabro,* no less than seventy-five names have been proposed for presumed discrete genera or subgenera within this assemblage. And almost from 1815, when Leach first advocated the division of *Crabro* into several genera,[1] until the present time, two diametrically opposed, vociferous and often militant schools of thought have flourished: that exemplified by such authors as Lepeletier and Brullé, Dahlbom, Morawitz, Thomson, and Ashmead who have divided the group into an ever increasing number of genera and subgenera, and countervailingly those who like Westwood, Shuckard, Smith, Kohl, Fox, and most recently Arnold, have relegated into synonymy the names of previous authors and united almost all the species into one large, all inclusive, portmanteau genus *Crabro.* Arguments can be adduced in support of each thesis.

These wasps are exceedingly, often bewilderingly, protean in their characteristics. They are divisible into innumerable natural groups, some of which are very well marked, while others are difficult to separate out, or apparently differ in points that exist in but one sex. Since the first attempt at a supraspecific classification of these wasps by Lepeletier and Brullé over a century ago,[2] each subsequent worker, as he perceived some apparently new and striking feature, too often made it forthwith the basis of a new genus or subgenus, frequently without adequately consulting and reviewing the work of his predecessors and contemporaries, with the result that Pelion has been piled on Ossa and that in turn upon Olympus. Moreover, until recently, uncertainty and conflicting opinion as to what properly constituted the correct specific

1 In his article on Entomology in Brewster's Edinburgh Encyclopaedia, Leach gave three species as exponents of *Crabro: cribrarius, subterraneus,* and *tibialis,* with the statement that these three species could be considered the types of as many genera. The subsequent history of the group has long since confirmed the accuracy of Leach's observation.

2 Lepeletier de St. Fargeau and Brullé gave the first elaborate generic classification of these wasps in 1835 [Ann. Soc. Ent. France, III, pp. 683-810]. In their monograph they recognized eleven genera: *Crabro* and ten others which they then erected: *Solenius, Blepharipus, Ceratocolus, Thyreopus, Thyreus, Crossocerus, Lindenius, Dasyproctus, Corynopus* and *Physoscelus.* Although they were unaware of the fact, their groups *Physoscelus* and *Corynopus* combined were the equivalent of Kirby's 1829 genus *Rhopalum,* now an absolute synonym of *Euplilis* Risso, 1826, while their *Ceratocolus* was congeneric with Billberg's long unnoticed 1820 name *Lestica.*

type of each of this multitude of names has added materially to the existing confusion. Confronted with this ever increasing, perplexing and apparent plethora of generic and subgeneric names, too many of which were ill defined, poorly understood, contradictory, and often synonymous, it is little wonder therefore that modern authors, bewildered by this nomenclatorial incubus, have usually chosen to reject and consign to synonymic oblivion most if not all the names of previous investigators rather than face the prospect, let alone the pangs of taxonomic dyspepsia.

The present state of confusion is due largely to the fact that, save for Kohl's effort[3] in 1896 and three years later the somewhat unsatisfactory endeavour of Ashmead,[4] no comprehensive survey of the Pemphilid supraspecific categories has ever been presented. Indeed until the present, practically every investigation of these wasps has been limited, often of necessity it is true, to the fauna of but a single region or subregion. And therein lies the basis of most difficulties encountered by modern authors.

The European and Nearctic Pemphilid fauna has naturally been more fully investigated and described than that of any other region. As the Neotropical and Ethiopian, the Australian and Oriental species have been described, they have usually been thrust willy-nilly into some Palaearctic or Nearctic classificatory pigeon hole, convenient and readily available perhaps, but often ill suited to them. For of the seventy-five categories proposed to date, no less than fifty-four or almost three-fourths the sum total of all names proposed, are based upon European or North American species.[5] Conversely, in the Neogaeic Realm, which, by reason of its long isolation, has developed one of the richest and most distinctive faunas in this group, only five categories have been recognized.[6] A similar condition prevails in the remaining regions: the Ethiopian has merely five[7] also, and the Hawaiian a like number,[8] the Oriental region but one,[9] and the Australian none. This does not necessarily imply, however, that Holarctic groups are absent from the other zoogeographic regions; they generally are present, sometimes relatively unaltered in their facies, but other times in such a modified guise or derived form that recognition as discrete subgenera, or even genera, may not be inappropriate now if they are considered in the light of their relationship to the whole

3 Kohl: Ann. k. k. Naturhist. Hofmus. Wien, XI, pp. 476-495; 499-500, (1896).

4 Ashmead: Canad. Entom., XXXI, pp. 163-174; 212-220, (1899).

5 Of these fifty-four generic or subgeneric names, approximately two-thirds are based upon Palaearctic species and but one-third on North American forms.

6 Neotropical groups: *Podagritus* Spinola, 1851. *Ischnolynthus* Holmberg, 1902. *Entomocrabro* Kohl, 1905. *Holcorhopalum* Cameron, 1904. *Merospis* Pate, 1941.

7 Ethiopian groups: *Dasyproctus* Lepeletier & Brullé, 1835. *Megapodium* Dahlbom, 1844 (emended by Schulz in 1906 to *Megalopodium*) a synonym of *Dasyproctus*. *Neodasyproctus* Arnold, 1926. *Microcrabro* Saussure, 1892.

8 Hawaiian groups: *Nesocrabro* Perkins, 1899; and *Hylocrabro*, *Melanocrabro*, *Oreocrabro* and *Xenocrabro*, all erected by Perkins in 1902. *Cf.* discussion of these groups under the genus *Ectemnius*.

9 Oriental groups: *Hingstoniola* Turner & Waterston, 1926.

world fauna of the group. Indeed, certain entities like *Anacrabro, Entomocrabro,*[10] *Enoplolindenius,*[11] *Quexua,*[12] and *Dasyproctus* are so distinct as a result of their long isolation in some one or several closely adjacent regions that there cannot be the slightest question they now represent and must be regarded as discrete genera. And finally, if these be accorded distinct taxonomic and nomenclatorial rank, then the large residue of species must be allocated to their natural genera and subgenera.

Undoubtedly the most outstanding contributions to the classification of these wasps are embodied in Kohl's treatment of the group in his 1896 review of the Sphecoid genera[13] and in his magnificent masterpiece "Die Crabonen der paläarktischen Region"[14] published two decades later. In each paper Kohl recognized only two genera: first, the New World entity *Anacrabro,* and secondly, a large comprehensive genus *Crabro* which, however, he divided into a finely organized series of segregates termed "Hauptartengruppen," each of which consisted of a nicely integrated aggregation of "Artengruppen" and their subordinate "Gruppen." To each category Kohl applied, insofar as such were available, generic or subgeneric names proposed by previous authors. This ultraconservative classification of Kohl is in sharp contrast to Ashmead's proposal in 1899 that the old genus *Crabro,* together with the Neogaeic *Anacrabro,* should constitute an independent family of thirty-eight discrete genera distributed among five distinct subfamilies. Yet irreconcilably antithetical though they seem, the systems of Kohl and Ashmead are not so dissimilar and incompatible as they appear at first glance. The difference between the two is mainly one of degree: the "Hauptartengruppen" and "Artengruppen" and "Gruppen" of Kohl correspond in large measure to Ashmead's subfamilies and genera. But notwithstanding this, the two schools have continued their divergent ways; they have lumped and split to their heart's content and quarrelled enormously.

The conservatives have steadfastly contended it is foolhardy to accord the natural entities into which the Pemphilid wasps break up the rank of anything more than species groups, or subgenera at most. The late Franz Friedrich Kohl, the leading modern proponent of this school, has presented their thesis most brilliantly and masterfully in the following words:

> ... Der heutigen Entgleisung, die Zersplitterung nachweisbar natürlicher Artgruppen der bisherigen guten Gattungen ins masslose fortzusetzen, wie sie in neuerer Zeit bei manchen Hymenopterenfamilien eingerissen ist, vermochte der Verfasser nicht zu folgen. Diese Erscheinung bedeutet für sein Empfinden einen Mangel an Gefühl für

10 *Cf.* Pate: A Review of the genus *Entomocrabro.* Rev. Entom. (Rio de Janeiro), XII, pp. 45-61, (1941).

11 *Cf.* Pate: The New World Genera and Species of the Foxita Complex. Rev. Entom. (Rio de Janeiro), XIII, pp. 367-421, (1942).

12 *Cf.* Pate: On *Quexua,* a new genus of Pemphilidine Wasps from Tropical America. Rev. Entom. (Rio de Janeiro), XIII, pp. 54-75, (1942).

13 Ann. k. k. Naturhist. Hofmus. Wien, XI, pp. 476-500, (1896).

14 Ann. k. k. Naturhist. Hofmus. Wien, XXIX, pp. 1-452, (1915).

natürliche Verwandtschaft und ist manchmal vielleicht gar nur die Folge einer Sucht, neue Namen in die Wissenschaft einzuführen. Das Schlimme daran ist der Umstand, dass die neu hergestellten Gattungen keine Gattungen sind, weil die Merkmale, auf denen sie gegründet wurden, die eigentlichen Artmerkmale bedeuten, zu denen der Mehrzahl nach auch die sekundären Geschlechtsmerkmale gehören. Mit diesem Vorgehen erstirbt vor allem der Einblick in das Wesen und in das ganze oft sehr verworrene Gefüge der Verwandtschaft vollständig. Es wäre ein leichtes, bei den paläarktischen Crabronen die bereits begonnene Zersplitterung mit Hinweis auf schon vorhandene Beispiele so weit fortzusetzen, dass die alte Gattung *Crabro* aus gerade so viel Gattungen bestände, als sie Arten hat, also die ganze Zersplitterungssucht ad absurdum geführt wäre. . .15

Yet Kohl's arrangement of the various entities in a carefully organized plexus of descending series, wherein "Artengruppen" are subordinated to "Hauptartengruppen" and "Gruppen" to "Artengruppen," with the name of a previous author attached to practically every category, often coupled with the recognition of new groups and the proposal of names for them, refutes many of the most fervid arguments advanced by him and his disciples. Moreover, these taxonomic tories in labelling as genera-mongers afflicted with the itch and divers other grievous ills, — in branding as vexatious paralogists so submerged in rapt contemplation of minute trivia that their perspective of the whole has been lost or distorted, — needlessly exacerbate those who maintain the Pemphilid wasps comprehend a number of discrete genera and subgenera. But that too much ill advised and often unwarranted division within the complex has occurred in the past cannot be denied. Nevertheless to accept and employ today the ultraconservative, ponderous and unwieldy classification of Kohl seems no less impracticable than to follow to its uttermost ramifications Ashmead's immoderately radical system. Obviously a classification that will effect a reconciliation of these two divergent views and incorporate the better features of each is now urgently required in order to extricate the group from the taxonomic bog in which it has too long been mired. Detailed and critical analyses of the structural characteristics displayed by the various groups, evaluated, interpreted and combined with the data derived from a study of the distribution and ethology of the component forms, now indicate that many of the entities lightly dismissed in the past as mere figments of the taxonomic imagination represent and must be accorded the rank of discrete genera and subgenera. The prime object of the present paper is a preliminary exposition of this thesis.

Twenty-five genera are recognized as distinct here. Undoubtedly more will be discovered when the Neotropical, Ethiopian, Oriental and Australian faunas are more thoroughly known. However, in view of the tangle in which this group has existed for so long, caution is advised in the hasty proposal of any new groups. Moreover, I may have been overly sanguine both in the rank accorded some of the Neotropical entities described as new on the following pages and also in the recognition of so many subgeneric groups in certain large genera such as *Crossocerus* and *Ectemnius*. However, time and additions to our knowledge, which is still far from complete, will take care

15 Ex "Die Crabronen der paläarktischen Region." Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 2, (1915).

of this. For no classification, particularly a tentative one such as this purports to be, can ever hope to be perfect in every detail.

A key to the genera is presented on a following page. This will serve to differentiate the various genera and also to briefly characterize them. Diagnoses of many of the previously known groups have been given by Kohl in his monograph of the Palaearctic forms, a paper of such exquisite and painstaking character that it must inevitably be the basis of any future investigation of these wasps. I have recently presented reviews of several groups (*Entomocrabro, Foxita* and *Enoplolindenius, Quexua, Tracheliodes, Encopognathus,* the subgenera *Hoplocrabro* and *Blepharipus,* and the subgeneric categories of *Crossocerus*) and eventually, as opportunity permits, will tender illustrated and critical revisions of the remainder. In the following account, the subgeneric names and synonyms of each genus are given, together with a brief statement of the correct genotype of each name: detailed information about the latter may be found in my paper on the type species of the Sphecoid generic names.[16]

Basis of the Present Study.—This survey and tentative classification of the genera of Pemphilidine wasps is based upon an examination of a large amount of North American material, and in particular a study of the types of Cresson, Packard, Fox and several others. A representative collection of Palaearctic forms, determined largely by the late Franz Friedrich Kohl, has proven invaluable. Extensive Neotropical collections from the Guianas, Colombia, Brazil, Argentina, Chile, Peru and the Antilles taken by various Cornell University expeditions, the Oxford University Expeditions to British Guiana, and Drs. J. C. Bequaert, O. W. Richards, J. Smart, E. McC. Callan, and various others has served as a basis for a preliminary interpretation of the rich and varied fauna of this region. For the Orient, material taken in Formosa by Gressitt and Sauter; Philippine and Indian collections in the Museum of Comparative Zoölogy at Harvard; and a small but diversified lot from the East Indies through Dr. J. van der Vecht of Buitenzorg, Java, have all aided materially in understanding the faunal composition of this region. A small lot of Australian specimens in the Museum of Comparative Zoölogy has given a slight indication of some of the problems involved in a study of the fauna of that region. A few Hawaiian forms have also been studied. Finally, to Dr. George Arnold, Director of the National Museum of Southern Rhodesia, and Captain R. H. R. Stevenson, both of Bulawayo, I am particularly indebted for their extraordinary kindness in contributing specimens of many Ethiopian forms.

Ethology

The biology of the members of this general group is quite varied. The more generalized forms are terricolous and generally fossorial. Some such as *Anacrabro, Rhectognathus, Entomocrabro* and others, have developed a psammophore to aid them in the excavation of their burrows.[17] Many, however,

16 Mem. Amer. Ent. Soc., no. 9, (1937).

17 *Cf.* Barth: Bull. Wisconsin Nat. Hist. Soc., VI, pp. 147 *et seq.*, (1908). *V. et.*: Pate: Trans. Amer. Ent. Soc., LXVI, pp. 252-256, (1940).

have become xylicolous, nesting in brambles, canes, pithy stems like elder, and in the rotten wood of old logs and stumps. This latter habit has probably arisen from the custom which certain groups like *Cuphopterus* practice of utilizing for their nesting sites pre-existing holes, crannies, or the abandoned burrows of wood-boring beetles. An excellent index for the probable type of nesting habit is the shape of the pygidial area of the female: in terricolous forms, it is usually broad, flat and trigonal, whereas in xyloecetes it is generally strongly narrowed and more or less excavate apically. But this criterion is not absolute. There are a number of borderline cases like the subgenera *Cuphopterus* and *Acanthocrabro* which are xylicolous despite the fact that the pygidia are relatively broad, flat and trigonal. In 1934, Minkiewicz, in a very interesting review of the biology of the various groups of Sphecoid wasps, proposed the terms *Planicrabronides* or *Chthonocrabronides* for the fossorial terricolous forms, and *Dendrocrabronides* or *Coelocrabronides* for those that nested in stems and rotten wood.[18]

These wasps generally attack various Diptera, although some are quite catholic in their choice of provisions: microlepidoptera, caddis flies, sawflies, chalcids, and even mayflies are occasionally found stored in their nests. Many *Blepharipus* and *Lindenius* prey more or less exclusively upon Homoptera (Cicadellidae, Aphididae, etc.) or Heteroptera (Miridae). The genera *Encopognathus* and *Tracheliodes* are myrmecotherous, the latter restricting its attention wholly to worker ants of the Dolichoderine genera *Liometopum* and *Tapinoma*. Mirids and other Heteroptera form the exclusive prey of *Anacrabro;* while *Entomognathus* is largely if not wholly a predator upon Chrysomelid beetles, generally of the tribe Halticini.

The stored nests and burrows of these wasps are frequently parasitized by various Sarchophagid, Miltogrammine and Anthomyid flies, and Chrysid and Mutillid wasps. Detailed records of these will be given in the appropriate place as each genus or subgenus is eventually reviewed.

A brief statement of the biology of the various groups has been included under each genus on the following pages. This will be elaborated upon and discussed in detail as the various groups are revised. A compendium of the known biology of the various species was given by Kohl in his monograph of the Palaearctic forms.[19] In 1926 Hamm and Richards presented an excellent review of the ethology of the British species.[20] The recent papers of Maneval, and in particular those of Guido Grandi,[21] have added materially to our

18 Minkiewicz, R.—Nids et proies des Sphegiens de Pologne. Polski Pismo Ent., XII, pp. 181-256, (1934).

19 Kohl, F. F. Lebensweise der paläarktischen Crabronen. Ann. k. k. Naturhist. Hofmus. Wien, XXIX, pp. 352-440, ill. (1915).

20 Hamm, A. H. & O. W. Richards.—The Biology of the British Crabronidae. Trans. Ent. Soc. London, pp. 279-331, (1926).

21 Grandi has published these data chiefly in his excellently illustrated series of papers entitled: "Contributi alla conoscenza biologica e morfologica degli Imenotteri melliferi e predatori," published in the following journals: Redia, vol. XVI, (1925). Rivista di Scienze Naturali "Natura," vol. XVI, (1925). Boll. Lab. Zool. gen. agr. R. Scu. sup. Agric. Portici, vol. XIX, (1926). Mem. Soc. Ent. Ital., vols. V-VI, (1927-28). Boll. Lab. Ent. R. Ist. Sup. Agr. Bologna, vols. I-IX, (1929-37).

knowledge of the biology and morphology of the immature stages of many of the wasps.

KEY TO THE GENERA*

1. Abdominal tergites abruptly flexed under at the sides so that the ventral and dorsal portions of the tergites form a sharp edge at their junction; sternites flat or concave. Both sexes with pygidial area on last abdominal tergite. Eyes with inner orbits arcuate, divergent above and below; mandibles falcate, the apices simple and acuminate, the lower margins more or less excised. (New World forms) ..... *Anacrabro* Packard

Abdominal tergites not abruptly flexed under at the sides, at most only the first two with a sharp edge laterally; sternites more or less convex 2

2 (1). Maxillary palpi with five segments, labial palpi with three segments. Abdomen petiolate, the first segment more or less elongate, petiolate, and frequently nodose at apex 3

Maxillary palpi with six segments, labial palpi with three or four segments. Abdomen usually sessile or subsessile, occasionally petiolate 5

3 (2). Fore wings with the recurrent vein received toward the apical third of the cubital vein, the first abscissa of cubitus thus twice or more the length of second abscissa. Males as well as females with a distinct pygidial area on ultimate abdominal tergite. Mesopleura with prepectus sharply margined or angulate anteriorly. (Neotropical and Australian forms) ..... *Podagritus* Spinola

Fore wings with the recurrent vein received at or before the middle of the cubital vein, the first abscissa thus never more than one and a half times the length of the second. Only females with a distinct pygidial area on ultimate abdominal tergite 4

4 (3). Mesopleura with prepectus sharply margined anteriorly. Head cubical; occipital carina well developed, more or less flanged and a complete circle in extent; mandibles bidentate at apex, the lower tooth strongly divergent from the upper straight one, and armed basally on inner margins with a long acuminate spinoid tooth. Abdomen with first segment not appreciably nodose apically, and those distad of it fusiform (females) or gradually ampliate to the clavate apex (males). Hind tibiae obterete, not strongly clavate apically. Vertex and thorax usually very coarsely punctate. (Sonoran Nearctic forms) ..... *Moniaecera* Ashmead

Mesopleura with prepectus rounded, not sharply margined anteriorly. Head transversely subrectangular in dorsal aspect and broader than long; temples not well developed; occipital carina not well developed, neither flanged nor a complete circle in extent; mandibles with apices evenly bidentate, the lower tooth not strongly divergent from the upper one, and inner basal margin without such long acuminate spinoid tooth. Abdomen with first segment usually nodose at apex, and fusiform distad of it in both sexes. Hind tibiae more or less strongly clavate apically. Vertex and thorax at most finely punctate. (Cosmopolitan forms) ..... *Euplilis* Risso

5 (2). Labial palpi with three segments 6
Labial palpi with four segments 7

6 (5). Eyes with inner orbits parallel or subparallel, the face broad below and the antennal sockets remote from nearest lower inner orbit; front on anterior vertical aspect without a marginate scapal basin, and on dorsal horizontal plane not bisected by a longitudinal carinule; occipital carina

* *Hingstoniola* Turner & Waterston not included.

not a complete circle in extent, neither flanged nor foveolate. Pronotum generally ecarinate; mesonotum without transverse carinules anteriorly; mesopleura with prepectus sharply margined anteriorly but without a vertical carina before middle coxae; mesosternum rounded anteriorly; propodeum without lateral carinae. Fore trochanters slender, elongate. Males with middle tibiae usually with an apical calcar. (Holarctic forms) ..... *Tracheliodes* A. Morawitz

Eyes with inner orbits strongly convergent toward clypeus, the face narrow below, the antennal sockets contiguous to each other and to nearest lower inner orbit; front on anterior vertical aspect with a sharply marginate scapal basin, and on dorsal horizontal plane bisected by a longitudinal carinule; occipital carina a complete circle in extent and usually flanged and foveolate. Pronotum sharply transversely carinate. Mesonotum with a pair of transverse carinules anteriorly; mesopleura anteriorly on prepectus with a sharply carinate epicnemium which is continuous ventrally with a sharply margined mesosternum, and also with a sharp vertical carina before middle coxae; propodeum with well developed lateral carinae. Fore trochanters relatively short and normal. Males with middle tibiae lacking an apical calcar. (New World forms) ..... *Enoplolindenius* Rohwer

7 (5). Mesopleura with two epicnemia: a sharp and distinctly carinate one anteriorly on prepectus, and also a rather well developed one posteriorly on mesopleura to accommodate the middle legs. Dull, opaque, matt forms, with the first abdominal segment elongate, petiolate and usually strongly nodose at apex and separated from second segment by a strong constriction. (Ethiopian, Oriental, Australian, Eremian and Mediterranean forms) ..... *Dasyproctus* Lepeletier & Brullé

Mesopleura at most with only a sharply carinate epicnemium anteriorly on prepectus. More or less fulgid forms with the abdomen sessile or subsessile, seldom with the first segment elongate-petioliform and nodose at apex 8

8 (7). Mandibles more or less falcate, with the apices simple and acute. Males as well as females with a distinct pygidial area on last abdominal tergite, but never with a tibial shield on fore legs. Ocelli arranged in a curved line, a low or high isosceles or equilateral triangle 9

Mandibles with the apices bidentate, tridentate, or blunt and obliquely truncate (rarely simple, in which case the males have a tibial shield on on fore legs). Males generally without a distinct pygidial area on last abdominal tergite. Ocelli usually not arranged in a very flat triangle 16

9 (8). Mandibles entire beneath. Eyes naked. Mesopleura usually without a vertical carina before middle coxae 10

Mandibles with lower margins distinctly excised. Mesopleura sometimes with a vertical carina before middle coxae 14

10 (9). Mesopleura with a sharp and distinct vertical carina before middle coxae. Males without a pygidial area on last abdominal tergite 19

Mesopleura simple, without such carina before middle coxae. Males with a distinct pygidial area on last abdominal tergite 11

11 (10). Ocelli situated in a curved line or a very low and broad isosceles triangle; vertex without postocular tubercles. Hind wing with anal lobe longer than the short submedian cell. Abdomen sessile, the tergites with basal acarid chambers. (Holarctic and Oriental forms) ..... *Lindenius* Lepeletier & Brullé

Ocelli situated in a high equilateral triangle. Hind wing with anal lobe shorter than, or at most subequal in length to, the submedian cell.....12

12 (11). Abdominal tergites without basal acarid chambers. Both sexes with mandibles simple and acute at apex and with a pygidial area on last abdominal tergite. Vertex with distinct postocular tubercles 13

Abdominal tergites with basal acarid chambers. Only females with mandibles simple and acute at apex. Males without a pygidial area on last abdominal tergite. Vertex without postocular tubercles 19

13 (12). Abdomen sessile or subsessile, first segment never nodose at apex. Pronotum usually transversely carinate, the tubercles never attaining the tegulae. Temples with a vertical carina descending from postocular tubercles to hypostomal carinule or posterior articulation of mandibles. (Neotropical forms) .....*Quexua* Pate

Abdomen petiolate, the first segment nodose at apex. Pronotum ecarinate, the tubercles attaining the tegulae. Temples ecarinate. (Neotropical forms) [Type: *Amaripa thauma* new species] .....*Amaripa* new genus

14 (9). Eyes hairy; face usually broad below, the antennal sockets more or less well separated from each other. Fore wing with marginal cell elongate, two and a half to three times as long as wide; transverse cubital vein straight, oblique, inclivous; recurrent vein joining cubitus at or beyond the middle but not causing the latter to be appreciably angled backward. Hind wing with anal lobe generally longer than submedian cell. Mesopleura with or without a vertical carina before middle coxae. Abdominal tergites with basal acarid chambers. Females generally without a psammophore. (Cosmopolitan, except Australian Region).....*Entomognathus* Dahlbom

Eyes naked (rarely very finely and sparsely puberulent), and without such combination of characters 15

15 (14). Fore wing with marginal cell very short, only about twice as long as wide; transverse cubital vein straight, oblique, inclivous, joining the radial vein before the middle of the marginal cell; recurrent vein joining cubitus distinctly before middle of latter and causing it to be appreciably angled backward; first discoidal cell rhomboidal. Hind wing with anal lobe subequal in length to, or shorter than submedian cell. Mesopleura without a vertical carina before middle coxae but with foveolate hypersternauli present. Face narrow below, the antennal sockets contiguous to each other and to nearest lower inner orbits. Abdominal tergites without basal acarid chambers. Females with a psammophore. Fulgid, finely punctate, Neotropical forms.....*Entomocrabro* Kohl

Fore wing with marginal cell elongate, two and a half to three times as long as wide; transverse cubital vein usually angulate medially, the upper (anterior) ordinate straight and perpendicular, the lower (posterior) ordinate oblique and inclivous, transverse cubital vein joining radius about middle of marginal cell; recurrent vein joining cubitus at or beyond the middle but not causing the latter to be appreciably angled backwards; first discoidal cell trapezoidal. Hind wing with anal lobe generally longer than submedian cell. Face broad below, the antennal sockets relatively remote from each other or from the nearest lower inner orbit. Abdominal tergites generally with basal acarid chambers. Females often with a psammophore. (Cosmopolitan, except Australian Region) .....*Encopognathus* Kohl

16 (8). Fore wing with the recurrent vein received on the cubitus at or about the middle of the submarginal cell, the two abscissae of cubitus thus more or less subequal in length, the second abscissa at least distinctly longer

than the transverse cubital vein. Mesopleura usually without a vertical carina before middle coxae, though often with a sharp tubercle. Ocelli arranged in either a low isosceles or a high equilateral triangle. Antennae twelve-segmented in females and thirteen-segmented in males (rarely with but twelve segments but in such case males are furnished with a large tibial shield); antennal flagellum of males generally fringed beneath with hair 19

Fore wing with the recurrent vein received in outer third of submarginal cell, the second abscissa of cubitus thus much much shorter than the first abscissa and generally shorter than, or at most subequal in length to, the transverse cubital vein. Mesopleura generally with a vertical carina before middle coxae; mesopleura and propodeum usually distinctly, often coarsely punctured. Ocelli generally arranged in a low triangle. Antennae twelve-segmented in both sexes (except in *Neodasyproctus*); the flagellum of males rarely fringed beneath with hair..... 17

17 (16). Abdomen with first segment elongate-petioliform and more or less nodose at apex, twice to two and a half times as long as wide at apex and separated by a distinct constriction from remainder of abdomen. Occipital carina attaining posterior angles of the large campanulate oral fossa; clypeus with disc merely tumid, not keeled; antennae thirteen-segmented in males and twelve-segmented in females, the scapes ecarinate in both sexes; mandibular apices bidentate in males, tridentate in females, the inner margins edentate in both sexes. Propodeum short, gibbous, coarsely punctate throughout, and without trace of either a dorsal enclosure or lateral carinae. Males with an apical calcar on middle tibiae. Females with pygidial area broad, flat, trigonal. Fulgid South African forms with the head, thorax and propodeum coarsely punctate, the abdomen impunctate or at best very finely punctate..... *Neodasyproctus* Arnold

Abdomen sessile or subsessile, (rarely if ever with first segment petioliform, but in such case then without above combination of characters). Antennae twelve-segmented in both sexes..... 18

18 (17). Vertex with distinct supra-orbital foveae. Mesopleura very coarsely and deeply sculptured, the punctures not confluent; abdomen distinctly, often coarsely, punctate or sculptured. Males generally without an apical calcar on middle tibiae. (Widespread)..... *Lestica* Billberg

Vertex without or with very indistinct supra-orbital foveae. Mesopleura usually not coarsely punctate, but often horizontally striate; abdomen finely punctate or impunctate. Males generally with a distinct apical calcar on middle tibiae. (Cosmopolitan) ..... *Ectemnius* Dahlbom

19 (16). Mesopleura with a vertical, often foveate, carina before middle coxae. [10; 12] Antennal scapes usually carinate lengthwise 20

Mesopleura without a vertical carina before middle coxae, at most with a sharp tubercle there. Antennal scapes usually ecarinate 25

20 (19). Front with a concave, sharply and completely margined scapal sinus on anterior vertical aspect, and with dorsal horizontal plane bisected by a longitudinal carinule; occipital carina a complete circle in extent..... 24

Front without a concave, sharply marginate scapal sinus on anterior vertical aspect, and the dorsal horizontal plane not bisected by a carinule(or, if rarely, an incompletely margined scapal sinus and a very fine carinule bisecting dorsal face is present, then the occipital carina is not a complete circle in extent); occiptal carina either incomplete or a complete circle in extent 21

21 (20). Hind wings with the anal lobe but one-half, or at most two-thirds the

length of submedian cell. Occipital carina either a complete circle in extent or attaining the hypostomal carinule. Ocelli situated in a very low isosceles triangle 22

Hind wings with the anal lobe as long as or longer than the submedian cell. Occipital carina neither a complete circle in extent nor attaining the hypostomal carinule. Ocelli situated in a higher isosceles triangle 23

22 (21). Occipital carina attaining the posterior angles of hypostomal carinule; antennal scapes bicarinate lengthwise; males with mandibles falcate, simple and acuminate at apex; females with mandibles obliquely truncate at apex. Mesosternum and dorsal surface of pronotum rounded, ecarinate anteriorly; mesopleura perfulgid, with rather sparse puncturation and no trace of either mesopleurauli or hypersternauli. Fore wing with marginal cell squarely truncate at apex. (Neotropical forms) [Type: *Chimila paë* new species] ..... *Chimila* new genus

Occipital carina a complete circle in extent, strongly flanged, more or less foveolate, and on midventral line well separated from apex of hypostomal carinule; antennal scapes bicarinate lengthwise; females with mandibles bidentate at apex. Mesosternum and dorsal surface of pronotum sharply margined or carinate anteriorly; mesopleura fulgid, more or less impunctate, but strongly and horizontally costulate or striate, and with strong, well developed and usually foveolate mesopleurauli and hypersternauli. Fore wing with marginal cell obliquely truncate at apex. (Neotropical forms) [Type: *Paë paniquita* new species] ..... *Paë* new genus

23 (21). Mesosternum and dorsal surface of pronotum sharply and transversely margined or carinate anteriorly. Abdomen maculated with yellow, the first segment perfectly sessile with second. Antennal scapes unicarinate; front with an incompletely margined scapal sinus on anterior vertical face and dorsal horizontal plane bisected by a very fine, almost imperceptible carinule. Females with mandibles tridentate at apjex, and pygidial area not bisected by a longitudinal carinule. (Neotropical forms) [Type: *Taruma bara* new species] ..... *Taruma* new genus

Mesosternum and dorsal surface of pronotum rounded, not sharply margined anteriorly. Abdomen immaculate black, the first segment strongly nodose at apex and separated from second by a strong constriction. Antennal scapes bicarinate lengthwise. Front without trace of a marginate scapal sinus, or carinule bisecting dorsal face. Females with mandibles bidentate at apex; the pygidial area bisected by a longitudinal carinule. (Oriental and Australian forms) [Type: *Piyuma koxinga* new species] ..... *Piyuma* new genus

24 (20). Mesopleura with well developed sternauli. Temples with a foveolate groove along posterior orbits. Upper margin of scapal sinus projecting forward in a thin, down-curved, laminate plate over apices of scapes which are carinate lengthwise. Males with middle tibiae but one-half length of femora and without an apical calcar. Females without a small, opaque, finely and closely punctate spot anteriolaterally on each side of second abdominal sternite. (Oriental forms) [Type: *Crabro spinifrons* Bingham, 1897] ..... *Vechtia* new genus

Mesopleura with sternauli absent, though indications of foveolate hypersternauli may be evident. Temples simple, without such down-curved laminate plate; scapes unicarinate lengthwise. Males with middle tibiae subequal in length to femora and with an apical calcar. Females with a small opaque, finely and closely punctate, oval or ovate spot anteriolaterally on each side. (Neotropical forms) ..... *Foxita* Pate

25 (19). Ocelli arranged in a high, more or less equilateral triangle. Propodeum usually finely sculptured; generally with a delicately sculptured, trigonal

or semicircular enclosure on dorsal face. Males with flagellum generally fringed beneath with hair. (Cosmopolitan)..... *Crossocerus* Lepeletier & Brullé

Ocelli arranged in a curved line or low isosceles triangle. Propodeum coriaceous to clathrately areolate; dorsal face generally without a clearly defined enclosure. Females with a flat trigonal pygidial area. Males often with flagellum fringed beneath with hair, and fore tibiae with a large shield in some subgenera. (Holarctic and Neotropical forms) ..... *Pemphilis* Risso

ANACRABRO Packard

Anacrabro Packard, Proc. Ent. Soc. Philadelphia, VI, p. 67, (1866). [Type: *Anacrabro ocellatus* Packard, 1866.]

The sharply inflexed abdominal tergites and flat or concave abdominal venter cause *Anacrabro* to be the most distinctive and easily recognized genus of the Pemphilidine wasps.

Distribution.—This genus is confined wholly to the New World, and, although originally described and based upon a common and widespread Nearctic species, *A. ocellatus*, nevertheless *Anacrabro* is primarily an entity of the Neotropical Region where it is represented by half a dozen or more species. Several species, some of doubtful validity, have been described from Nearctic America.

Ethology.—The species of *Anacrabro* nest in dry or sandy soil. The females are generally provided with a well developed psammophore which they employ in the construction of their burrows. The cells are provisioned with Heteroptera, chiefly Mirids.

ENTOMOGNATHUS[22] Dahlbom

Entomognathus Dahlbom, Hymen. Europ., I, p. 295, (1844). [Type: *Crabro brevis* Van der Linden, 1829.]

The hairy eyes, and in addition the simple falcate mandibles excised on their lower margins and the presence of a distinct pygidial area in the males as well as the females, readily differentiates *Entomognathus* from all other Pemphilid genera. As here understood, the present complex is equivalent to the group which Kohl in 1915 defined as the "Artengruppe *Entomognathus*."[23]

Subgenera.—As in *Encopognathus*, the species comprising *Entomognathus* are divisible into several distinctive groups which may be accorded subgeneric rank. These are briefly characterized below, and will be more fully described and discussed in a forthcoming review of the genus.

KEY TO THE SUBGENERA OF ENTOMOGNATHUS

1. Mesopleura with well developed sternauli and a vertical carina before middle coxae; fore wing with marginal cell more or less obliquely truncate at apex; antennae with thirteen articles in males and twelve in females..... 2

22 The gender of *Entomognathus* is feminine, not masculine.
23 Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 310, (1915).

Mesopleura without sternauli or a vertical carina before middle coxae; fore wing with marginal cell more or less squarely truncate at apex, the costa not appreciably produced beyond apex; hind wing with anal lobe distinctly longer than submedian cell 3

2. Fore wing with costa distinctly produced beyond apex of marginal cell; hind wing with anal lobe distinctly shorter than submedian cell; eyes with posterior orbits not margined by a foveolate groove; pronotum ecarinate dorsally; (Oriental forms); [Type: *Entomognathus siraiya* new species] ..... *Koxinga* new subgenus

Fore wing with costa not produced beyond apex of marginal cell; hind wing with anal lobe distinctly longer than submedian cell; eyes with posterior orbits margined by a foveolate groove; pronotum generally with anterior dorsal margin transversely carinate or sharply margined; (South African forms); [Type: *Thyreopus (Entomognathus) apiformis* Arnold, 1926] ..... *Mashona* new subgenus

3. Antennae of both sexes twelve-segmented; abdominal tergites three to five or six with caudal margins more or less angulate medially; (New World forms); [Type: *Entomognathus texanus* Cresson, 1887 24] ..... *Toncahua* new subgenus

Antennae of males with thirteen, of females with twelve segments; abdominal tergites with caudal margins truncate, not angulate medially; (Old World forms) ..... *Entomognathus* Dahlbom

Distribution.—The genus *Entomognathus* is a moderate sized complex of about two dozen described species. Representatives of it occur in practically every major zoögeographic area of the world. No species are yet known from the Australian Region.

Ethology.—The species of *Entomognathus* are fossorial forms which excavate their burrows in sandy or clayey soil or in talus slopes. The nests are generally provisioned with Chrysomelid beetles, particularly those belonging to the tribe Halticini.

Entomognathus (Koxinga) siraiya[25] new species

The distinguishing features given for *Koxinga* in the foregoing key to subgenera will likewise serve at present to differentiate *siraiya* from the other described species of *Entomognathus*.

Type.—♂; Taihorinsho, Formosa. Elevation, about 100 metres. September 7, 1909.

Male.—6 mm. long. Fulgid black; the following stramineous: mandibles except red apices, clypeus, scape, pronotum dorsally to and including the tubercles, tegulae with two large spots, prepectus, axillae, scutellum, postscutellum, fore and middle coxae apically, hind coxae entirely, all trochanters, all femora apically, fore and middle tibiae entirely, hind tibiae with a broad streak lengthwise on anterior faces, all tarsi, and on abdominal tergites as follows: fourth with a narrow fascia, fifth and sixth almost entirely. Legs

24 Not to be confused with *Crabro texanus* Cresson, 1872, which is referable to the subgenus *Hypocrabro* of the genus *Ectemnius*.

25 After the Siraiya, a tribe of the Pepo group, who formerly inhabited the Kagi district in south-central Formosa.

exclusive of yellow maculation, and axillary sclerites, light brunneous. Abdominal venter and entire last segment, sordid badeous. Wings hyaline, iridescent; veins and stigma light brunneous.

Head fulgid; suborbicular, wider than high in anterior aspect; clypeus and lower front with a moderate vestiture of appressed silvery hair; upper front, vertex and temples with a thinner clothing of pubescence, that of vertex suberect and light aeneous. Eyes distinctly hairy; inner orbits narrowly separated below from antennal sockets, arcuately divergent above, posterior orbits not margined by a foveolate sulcus; front behind scapes shallowly concave, with a glabrous, nitidous subcircular area, bisected above by a faint impression running forward from the median ocellus and with fine, well separated, setigerous acupunctures. Vertex more sparsely punctate than front; ocelli in a curved line, the postocellar line subequal in length to the ocellocular distance, postocellar line bisected by a fine impression, a furrow running obliquely forward from each hind ocellus to upper inner orbits; temples ecarinate; occipital carina well developed, flanged, strongly foveolate, a complete circle in extent, tangent below to apex of hypostomal carinule. Antennae with scapes subcylindrical, ecarinate, three-fifths the vertical eye length; pedicel obterete, subequal in length to second flagellar article; flagellum simple, finely puberulent, first segment two-thirds length of second, ultimate article simple, terete, twice the length of penult segment; antennal sockets rather close to each other and to nearest lower inner orbit, antennocular line three-fifths the interantennal distance. Clypeus transversely subelliptical, median length three-eighths the vertical eye length; flat laterally, the disc strongly, ovally tumid, not bisected by a keel; the lobe medio-apically with a transverse, linear, subtruncate flange, broadly and shallowly retuse apically, and laterad and separated from this by a broad emargination with a sharp dentiform angle on each side. Mandibles falcate; apices acuminate; lower margins strongly excised medially; inner margin with a cleft obtuse dentiform angle medially.

Thorax perfulgid; dorsally with a thin vestiture of rather long, erect, subaeneous hair; pleura with more noticeable decumbent silvery hair; with a sparse, widely separated, fine setigerous acupuncturation throughout. Pronotum short, transverse; anterior dorsal margin broadly rounded, ecarinate; tubercles carinate anteriorly. Mesonotum simple; axillae moderate, the lateral edges broadly rounded, immarginate; scutellum flatly tumid, anterior margin with a deep efoveate furrow, immarginate laterally; postscutellum simple. Mesopleura anteriorly on prepectus with a very sharp margin which is continuous ventrally with the sharply margined anterior edge of mesosternum; episternal suture impressed, foveolate; mesopleural pit moderate; before middle coxae with a sharp vertical carina continuous below with the strong, subfoveate sternauli which are confluent anteriorly with the omauli; metapleura with fine, sparse, setigerous acupuncturation. Propodeum fulgid, very short; with a thin vestiture of short, erect, light hair; dorsal face transversely linear, medially with a row of about six rather small, subrectangular areoles, laterad of which on each side is a large subtrigonal enclosure punctate and somewhat irregularly rugulate within; posterior face truncate, vertical, sharply carinate

above, disc with a narrow, marginate, subcampanulate areole, more or less open and irregularly rugulate above, nitidous, glabrous, perfulgid within, acute and shortly stalked ventrally, lateral surfaces finely punctate; lateral carinae well developed throughout, simple below; lateral faces with fine, well separated, setigerous acupuncturation.

Fore and middle legs relatively simple; fore metatarsi moderately flattened. Middle tibiae with an apical calcar; not appreciably spinose on outer faces. Hind femora subfusiform; hind tibiae thickened and greatly enlarged toward apex, their outer faces with several rows of fine spinules; longer hind tibial calcar one-half the length of much thickened hind metatarsi which are longer than four distal segments combined.

Fore wing with marginal cell at least three times as long as wide, with costa distinctly produced beyond the obliquely truncate apex; radial vein with second abscissa four-fifths the length of first abscissa; transverse cubital vein straight, oblique, inclivous, subequal in length to second abscissa of cubitus which in turn is one-third the length of first cubital abscissa. Hind wing with anal lobe distinctly separated off, and four-fifths the length of submedian cell.

Abdomen fulgid; with a thin vestiture of decumbent hair; somewhat constricted between the segments; basal acarid chambers very well developed. Tergites and sternites with a uniform, moderately coarse, separated, setigerous puncturation throughout. First five tergites with a distinct translucent flange along truncate caudal margins; last tergite with a subquadrate, strongly margined pygidial area, the disc coarsely punctate, apical margin flatly rounded.

Allotype.—♀; Topotypical. Same data as type.

Female.—7 mm. long. Agrees with male (type) except as follows:

Livery much the same but abdomen bright ferruginous and without yellow maculation. Scutellar disc black.

Head the same but with shallow, rather poorly defined, broad sublunate supra-orbital foveae. Antennocular line three-eighths the interantennal distance. Clypeus with median length one-half the vertical eye length; laterad of apical flange with two small teeth on each side.

Fore tarsi without an appreciable pecten. Middle and hind tibiae spinulose on outer faces.

Abdomen in general the same. Pygidial area broad and equilaterally trigonal, apex narrowly rounded, disc flat, coarsely punctate and furnished with decumbent aeneous setulae.

This distinctive species is described from a series of males and females, all taken at Taihorinsho, Formosa. All agree with the typical pair in all essential features.

ENCOPOGNATHUS[26] Kohl

Encopognathus Kohl, Ann.k. k. Naturhist. Hofmus. Wien, XI, p. 486, (1896). [Type: *Crabro (Encopognathus) Braueri* Kohl, 1896.]

26 The gender of *Encopognathus* is feminine, not masculine as hitherto believed and recorded.

Rhectognathus Pate, Entom. News, XLVII, p. 147, (1936). [Type: *Encopognathus (Rhectognathus) pectinatus* Pate, 1936.]

Tsaisuma Pate, Lloydia, VI, p. 57, (1943). [Type: *Lindenius wenonah* Banks, 1921.]

Aryana Pate, Lloydia, VI, p. 68. (1943). [Type: *Encopognathus (Aryana) oxybeloides* Pate, 1943.]

The genus *Encopognathus* is a small relict complex divisible into four distinct subgenera: the Nearctic entities *Tsaisuma* Pate and *Rhectognathus* Pate, the Oriental *Aryana Pate,* and the nominate group which is confined to the Ethiopian Region. A review of the taxonomy, distribution and ethology of *Encopognathus* has been presented recently elsewhere.[27]

Distribution. — The genus *Encopognathus* has a wide but discontinuous distribution. Representatives of it are known from western North America, the Mediterranean region, India, and South Africa.

Ethology.—The species of *Encopognathus* are fossorial, myrmecotherous forms.

ENTOMOCRABRO Kohl

Entomocrabro Kohl, Verh. k. k. Zool.-Bot. Ges. Wien, LV, p. 356, (1905). [Type: *Crabro (Entomocrabro) Dukei* Kohl, 1905.]

The diagnostic characters of *Entomocrabro* have been presented in the foregoing analytical key to the genera. A review of this interesting little genus and its component forms has been recently published elsewhere.[28]

Distribution.—The genus *Entomocrabro* is a small complex confined wholly to the Neotropical Region, where it ranges throughout the Amazonian basin in Brazil and the intermontane region of central Peru to as far north as the central west coast area of Guatemala. Five species are known at present.

Ethology.—The biology of the group is unknown. However, inasmuch as the females are usually furnished with a rather well developed psammophore and in addition have a broad, flat, coarsely punctate, trigonal pygidial area, the species in all probability are fossorial forms.

Amaripa[29] new genus

The general habitus of *Amaripa* is very similar to that of *Euplilis,* but the sharply margined and epicnemiate prepectus, the simple falcate mandibles, and the different number of segments in the palpi readily separates the present entity from that genus.

The closest ally of *Amaripa* is the preceding Neogaeic entity *Entomocrabo* with which it agrees in the basic structure of the thorax, particularly the mesopleura, the simple falcate mandibles, and the main venational fea-

27 *Cf.:* Pate: On the Taxonomy of the genus *Encopognathus.* Lloydia, VI, pp. 53-76, (1943).

28 *Cf.* Pate: A Review of the genus *Entomocrabro.* Rev. Entom. (Rio de Janeiro), XII, pp. 45-61, (1941).

29 After the Amaripa Indians of British Guiana.

tures of the fore and hind wings. Moreover, like *Entomocrabro*, the present genus lacks basal acarid chambers on the abdominal tergites. But the petiolate abdomen, the non-emarginate inferior mandibular margins, the much longer marginal cell of the fore wing, and the absence of supra-orbital foveae on the vertex, readily differentiate *Amaripa* from *Entomocrabro*.[28] Finally, the present genus is unique in the Pemphilidine wasps in that the pronotal tubercles attain the tegulae.

Generic Characters. — Small, at most finely punctate, perfulgid forms. Head subquadrate in anterior aspect, transversely subrectangular in dorsal aspect. Eyes large, apparently naked,[30] much more coarsely facetted anteriorly than posteriorly; inner orbits arcuate anteriorly and below to strongly divergent above; malar space wanting. Front below between inner orbits narrow, shallowly concave, but without a concave marginate scapal sinus; bisected above by a strong furrow running forward from anterior ocellus. Vertex flat; supra-orbital foveae absent; ocelli large, their diameter subequal in length to postocellar line, arranged in an equilateral triangle, the postocellar line much shorter than the ocellocular distance; a sharp tubercle behind each compound eye; temples moderate, simple, ecarinate; occipital carina distinct but not strongly flanged nor a complete circle in extent, nor attaining the hypostomal carinule. Antennae twelve-segmented in females; situated low on face on dorsal margin of clypeus, the sockets contiguous to each other and to nearest lower inner orbit; scapes cylindrical, ecarinate, slightly bowed, more than half the vertical eye length; pedicel cylindrical elongate, longer than either first or second flagellar articles; flagellum simple. Clypeus short, transverse, usually with a short produced lobe medioapically, the disc not keeled. Maxillary palpi with six, labial palpi with four segments. Mandibles subfalcate; apices simple, acuminate; lower margins entire; inner margins with a cleft obtuse prominence on basal half. Females without a distinct psammophore.

Thorax with pronotum situated slightly below level of the lightly arched mesonotum, and rounded, not transversely carinate anteriorly, the lateral angles rounded, the tubercles flat and attaining the tegulae. Mesonotum ecarinate, but may be otherwise variously modified; axillae prominent, with lateral margins sharply reflexed upward into laminate plates; scutellum and postscutellum relatively simple. Mesopleura anteriorly with a sharply margined epicnemium; both episternal suture and hypersternauli present, distinct and strongly foveolate; episternauli, mesopleurauli and sternauli absent; mesopleural pit large and distinct; simple, neither carinate nor tuberculate before middle coxae. Mesosternum rounded, not transversely carinate anteriorly. Propodeum with dorsal face more or less areolate; lateral carinae present and well developed, bifurcate ventrally.

Legs relatively simple; fore tarsi not flattened in females. Pulvilli very small and inconspicuous; claws very slender, elongate, and almost straight, subchelate.

Fore wing with the marginal cell three times as long as wide, broadly

30 Very finely and sparsely puberulent under a magnification of 120 diameters.

truncate at apex and with a large trigonal, though indistinct, appendiculate cell; radial vein with the first abscissa four-sevenths (.572) the length of second abscissa; transverse cubital vein straight, oblique, inclivous, one-third the length of second abscissa of cubitus; submarginal cell irregularly subhexagonal, the cubitus distinctly angled backward at point of reception of the arcuate recurrent vein; cubitus with first abscissa three-fifths the length of second abscissa; first discoidal cell small, irregularly rhomboidal. Hind wing with anal lobe large and slightly longer than the submedian cell.

Abdomen petiolate, the first segment nodose at apex and separated from the first segment by a distinct constriction; remainder of abdomen fusiform. Tergites without basal acarid chambers and finely punctate at most; ultimate tergite of females with a broad, flat trigonal pygidial area.

GENOTYPE: *Amaripa thauma* new species.

Amaripa thauma[31] new species

The curiously formed mesonotum and axillae, and the bristly legs readily differentiate this peculiar little species from all of its allies in the Neotropical Region.

Type.—♀; Moraballi Creek, Essequibo River, British Guiana. September 19, 1929. (Oxford University Expedition.) [British Museum (Natural History).]

Female.—4.25 mm. long. Black; the following flavofulvous: trophi, palpi, mandibles except red apices, clypeal disc, antennal pedicel and scapes; pronotal tubercles, tegulae and axillary sclerites, fore legs entirely, middle legs distad of coxae, hind coxae, trochanters and base and apex of femora and base of tibiae. The following castaneous: basal third of third abdominal tergite, abdominal venter, entire last abdominal segment, middle coxae, hind femora except base and apex, hind tibiae largely, and hind tarsi entirely. Wings clear hyaline, iridescent; stigma and veins dark castaneous.

Head perfulgid; clypeus, except glabrous disc, with long appressed sericeous silvery pubescence; temples with a thin vestiture of long appressed lanate silvery hair. Front on lower vertical aspect between inner orbits narrow, perfulgid, glabrous, nitidous, shallowly concave, simple and unarmed, without a marginate scapal sinus but traversed by fine parallel horizontal rugulae; upper portion of front and vertex perfulgid, glabrous, nitidous, bisected anteriorly by a strong longitudinal impression running forward from anterior ocellus, upper inner orbits paralleled by a row of long erect, convergent, bristle-like setae (like the outer vertical bristles of Muscoidean flies); supraorbital foveae absent but a large poorly defined circular depression near each hind ocellus between them and the nearest upper inner orbit; ocelli rather large, arranged in an equilateral triangle, the postocellar line four-ninths (.45) the ocellocular distance; a short longitudinal furrow bisecting the postocellar

31 From *thauma*, a wonder or marvel; in allusion to the unusual habitus of the species.

line; a sharp tubercle, which is concave at tip, just behind each compound eye; a transverse row of erect bristle-like setae between the postocular tubercles; temples perfulgid, with scattered setigerous acupuncturation, and a short impression running dorsad from posterior mandibular condyles, otherwise simple and ecarinate; occipital carina sharp, distinct, finely foveate anteriorly, but neither flanged, a complete circle in extent, nor attaining the hypostomal carinule. Antennae elongate; scapes cylindrical, slightly bowed, ecarinate, about seven-tenths (.727) the vertical eye length; pedicel cylindrical, elongate one and three-fourths the length of first flagellar article; flagellum simple, finely puberulent, first two segments subequal in length, ultimate article simple, terete, twice the length of penult segment. Clypeus short, transverse, median length about one-fourth (.272) the vertical eye length, with a strongly tumid to subtuberculate, glabrous and nitidous disc, laterad of which on each side the surface is strongly concave, produced medio-apically into a short, broad truncate lobe. Mandibles falcate, the outer faces with long, suberect, bristle-like setulae; lower margins entire; apices simple, acuminate; inner margins on basal half with an obtuse prominence cleft medially. No psammophore present.

Thorax more or less perfulgid; pronotum situated somewhat below level of mesonotum; with a moderately heavy vestiture of lanate decumbent silvery pubescence; dorsal face ecarinate anteriorly; lateral angles rounded; pronotal tubercles flat, attaining the tegulae. Mesonotum gently arched, anteriorly and laterally with a thin vestiture of long, appressed, silvery hair, the disc perfulgid and with a few scattered, erect, long, setulae, bisected on anterior half by a longitudinal welt, laterad of which on each side is a deep, elongate subcuneate fovea, hind angles just in front of axillae produced into a thick, conical, backward projecting, spinoid tubercle; axillae with a rather heavy vestiture of appressed to erect long silvery hair, lateral margins strongly reflexed upward to form a thin, translucent, incurved laminate plate; scutellum perfulgid, laterally with a thin vestiture of long decumbent silvery hair, very sparsely acupunctate, the anterior margin efoveate, but anterior half with a wide, deep, concave, transverse trough, the posterior half strongly tumid; postscutellum flat, simple, finely puberulent. Mesopleura on prepectus and anterior face with appressed, silvery lanate hair, remainder perfulgid, nitidous and glabrous; prepectus anteriorly with a sharply margined epicnemium; somewhat inflated behind the strongly impressed and foveate episternal suture; mesopleural pit large, distinct; posterior margin simple, efoveate; hypersternauli well developed for entire length and strongly foveate; episternauli and sternauli both absent; simple, neither carinate nor tuberculate before middle coxae. Metapleura glabrous, nitidous, hind margin coarsely foveate. Mesosternum with a thin vestiture of appressed silvery pubescence, and rounded, not transversely carinate anteriorly. Propodeum with a moderate vestiture of suberect, silvery hair on posterior face, otherwise glabrous and perfulgid; dorsal face discally with a large trapeziform area delimited by carinae and divided into three areoles: the median one large and suborcate, the lateral ones elongate subrectangular, the lateral areas of dorsal face traversed by a few indistinct irregular regulae; posterior face separated from dorsal face by a transverse, curved,

multiangulate carinule, and bisected by a deep, immarginate, vertical furrow, laterad of which the surface is finely acupunctate; lateral carinae strong, well developed for entire length, and bifurcate below; lateral faces glabrous, nitidous.

Legs relatively simple. Femora with a few elongate setae. Tibiae and tarsi with a rather heavy vestiture of long, decumbent to suberect white hair and bristle-like setulae. Fore and middle tibiae with a strong bristle, subequal in length to metatarsi, just behind the apical calcar. Hind tibiae with two aciculate calcaria, the longer one-half the length of hind metatarsi. Fore tarsi very hairy but without a distinct pecten. Pulvilli very small, inconspicuous. Claws simple, slender, almost straight, elongate, and subchelate.

Abdomen perfulgid; petiolate, the first segment slender, twice as long as wide at apex, distinctly nodose at apex and separated there by a strong constriction remainder of fusiform abdomen which has a very sparse vestiture of short decumbent aeneous setulae which are longer, suberect to erect along apical margins of segments. Tergites without basal acarid chambers; with sparse and scattered, fine setigerous acupuncturation; ultimate tergite with a broad flat trigonal pygidial area which is glabrous, nitidous and perfulgid. Sternites subglabrous, subnitidous.

This curious and interesting little form of the tropical Guianan forest is known only from the unique female described above.

LINDENIUS Lepeletier & Brullé

Lindenius Lepeletier & Brullé, Ann. Soc. Ent. France, III, p. 791, (1835). [Type: *Crabro albilabris* Fabricius, 1793.]

Chalcolamprus Wesmael, Bull. Acad. R. Sci. Belg., XIX, p. 590, (1852). [Type: *Crabro albilabris* Fabricius, 1793. Isogenotypic with *Lindenius* Lepeletier & Brullé 1835.]

Trachelosimus A. Morawitz, Bull. Acad. Sci. St. Petersbourg, IX, p. 249, (1866). [Type: *Crabro armatus* Van der Linden, 1829.]

The genus *Lindenius* as here understood, is equivalent to the group which Kohl defined in 1915 as the "Artengruppe *Lindenius*."[32] The complex is a relatively compact entity, although *Trachelosimus* of Morawitz seems to form a distinct phyletic unit within it and may eventually be recognized as a valid subgenus.

Distribution.—The genus *Lindenius* is primarily Holarctic in distribution, poorly represented in the Orient, and apparently absent from the Neotropical, Australian and Ethiopian Regions.

Ethology.—The species of *Lindenius* nest in sandy ground and provision their burrows chiefly with small Diptera (Chloropidae, Dolichopodidae, Simuliidae, Trypetidae, etc.), and Heteroptera (Miridae). One species (*Lindenius armatus*) is reported to store its nests with small parasitic Hymenoptera (Chalcididae: *Pteromalus;* and Braconidae: *Apanteles*).

32 Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 272, (1915).

TRACHELIODES A. Morawitz

Brachymerus Dahlbom, Hymen. Europ., I, p. 525, (1845). [*Nec* Chevrolat, 1841.] [Type: *Crabro (Crossocerus) curvitarsus* Herrich-Schaeffer, 1840.]

Tracheliodes A. Morawitz, Bull. Acad. Sci. St. Petersbourg, IX, p. 249, (1866). [Type: *Crabro (Crossocerus) curvitarsus* Herrich-Schaeffer, 1840.]

Fertonius Pérez [in Ferton], Act. Soc. Linn. Bordeaux, XLIV, p. 341, (1892). [Type: *Crabro 5-notatus* Jurine, 1807.]

The broad face, with the inner orbits subparallel and not strongly convergent below as in most of the other genera of this complex, and the six-segmented maxillary and three-segmented labial palpi distinguish *Tracheliodes* from all other members of the Pemphilid wasps. A monograph of the genus has been presented recently elsewhere.[33]

Distribtuion.—The genus *Tracheliodes* is a small relict entity confined for the most part to the Holarctic Region, with a few species in Assam, Burma and eastern China. The range of the various species is apparently closely correlated with those of the ants upon which the wasps prey.

Ethology.—The species of *Tracheliodes* either excavate their burrows in the soil or utilize abandoned holes made in trees by wood-boring beetles. The nests are stored with worker ants of the Dolichoderine genera *Liometopum* or *Tapinoma*.

PEMPHILIS Risso

Crabro Fabricius, Syst. Entom., (Char. Gen., p. 12), p. 373, (1775). [*Nec* Geoffroy, 1762.] [Type: *Vespa cribaria* Linnaeus, 1758. Isogenotypic with *Pemphilis* Risso, 1826, *q. v.*]

Pemphilis Risso, Hist. Nat. Europ. Merid., V, p. 227, (1826). [Type: *Vespa cribaria* Linnaeus, 1758.]

Thyreopus Lepeletier & Brullé, Ann. Soc. Ent. France, III, p. 751, (1835). [Type: *Vespa cribaria* Linnaeus, 1758. Isogenotypic with *Pemphilis* Risso, 1826, *q. v.*]

Anothyreus Dahlbom, Hymen. Europ., I, pp. 519 & 526, (1845). [Type: *Crabro lapponicus* Zetterstedt, 1838.]

Thyreocnemus A. Costa, Ann. Mus. Zool. Napoli, VI, p. 64, (1871). [Type: *Thyreocnemus pugillator* A. Costa, 1871.]

Paranothyreus Kohl, Ann. k. k. Naturhist. Hofmus. Wien, XI, p. 490, (1896). [Type: *Crabro hilaris* F. Smith, 1856.]

Synothyreopus Ashmead, Canad. Entom., XXXI, p. 213, (1899). [Type: *Crabro tumidus* Packard, 1867.]

Dyscolocrabro Kohl, Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 138, (1915). [Type: *Crabro (Thyreopus Dyscolocrabro) chalybeus* Kohl, 1915.]

Agnosicrabro Kohl, Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 138, (1915). [Type: *Crabro occultus* Fabricius, 1805.]

Hemithyreopus Kohl, Ann. k. k. Naturhist. Hofmus. Wien XXIX, p. 138, (1915). [Type: *Crabro (Ceratocolus) Loewi* Dahlbom, 1845.]

Parathyreopus Kohl, Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 138, (1915). [Type: *Crabro filiformis* Radoszkowski, 1877.]

This is the nominate genus of the present large complex of the Sphecoid

33 *Cf.*: Pate: A Review of the myrmecotherous genus *Tracheliodes*. Lloydia (Cincinnati), V, pp. 222-244, ill., (1942).

wasps. Most authors have employed Lepeletier and Brullé's name *Thyreopus* for it, a few have used *Crabro* Fabricius, but, as explained below, *Pemphilis* Risso is adopted here.

The genus *Pemphilis* is practically identical with the group which Kohl in 1915 defined as the "Artengruppe *Thyreopus*."[34] About seventy species are referable to *Pemphilis* which is divisible into at least nine distinct subgenera: *Pemphilis* in the restricted sense, of which *Crabro* Fabricius and *Thyreopus* Lepeletier & Brullé are absolute synonyms; *Synothyreopus* Ashmead; *Parathyreopus* Kohl; *Thyreocnemus* A. Costa; *Anothyreus* Dahlbom; *Paranothyreus* Kohl; *Agnosicrabro* Kohl; *Hemithyreopus* Kohl; and *Dyscolocrabro* Kohl.

Distribution.—The present genus is primarily Holarctic in distribution, although a few species occur in the northern portion of the Neotropical Region. Apparently there are no representatives of *Pemphilis* in the Ethiopian, Oriental or Australian faunas.

Ethology.—The species of *Pemphilis* nest in dry or sandy soil, or rotten wood if sufficiently soft, and provision their nests with a variety of Diptera.

Nomenclatorial Notes.—In 1775 Fabricius established the genus *Crabro*[35] for a somewhat miscellaneous assortment of thirteen species. As a consequence of the designation by Latreille,[36] and various subsequent authors as well, of *Vespa cribaria* Linnaeus, 1758, as genotype, the name *Crabro* has been associated with some entity of the present group of Sphecoid wasps for well over a century and half. Fabricius' use of the name *Crabro,* however, was considerably antedated by Geoffroy who first employed it for the sawfly customarily known as *Cimbex.*[37] Though Fabricius eventually, and subsequent authors likewise, were aware of Geoffroy's name, they chose to ignore it, save in bibliographic citations. Indeed, it was not until Bradley in 1919 published his excellent critique[38] of Morice and Durrant's scholarly exposition of the "Erlangen List"[39] that Geoffroy's name was brought forcibly to the attention of modern hymenopterists. As Bradley pointed out, Geoffroy's usage of *Crabro,* though not binomial, was binary:[40] the generic name was uninomial and must therefore under the zoölogical code be accepted. Thus since *Crabro* Fabricius, 1775, is a homonym of *Crabro* Geoffroy, 1762, it is invalid, and, save as a matter of bibliographic record, is of no further consequence in the present group.

The next generic name proposed in the present group was *Lestica* Billberg, 1820.[41] This, as a result of Rohwer's designating *Crabro subterraneus* Fabri-

34 Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 133, (1915).
35 Fabricius: Syst. Entom., pp. 12 & 373, (1775).
36 Latreille: Consid. Gener., Tabl. Method., p. 438, (1810).
37 Geoffroy: Hist. abr. Insect., II, p. 261, (1762).
38 Bradley: Trans. Ent. Soc. London, pp. 50-75, (1919).
39 Morice & Durrant: Trans. Ent. Soc. London, pp. 339-436, (1915). *V. et.:* Idem, pp. 432-442, (1917).
40 Bradley: Trans. Ent. Soc. London, p. 66, (1919).
41 Billberg: Enumerat. Insect., p. 107, (1820).

cius, 1775 as genotype,[42] is now applicable to the section of this general complex which has hitherto gone under the name *Ceratocolus* Lepeletier & Brullé, 1835. But inasmuch as I now believe these wasps comprehend a number of discrete genera, Billberg's name is of no further import at the present juncture. Nevertheless, it must be borne in mind by those who opine these wasps comprise but a single large genus, that Billberg's name *Lestica* must be used for it, and furthermore, that the supra-generic groups in turn be called the Lesticini and Lesticinae.

The next generic names to appear in this assemblage were Risso's *Pemphilis* and *Euplilis*,[43] both of which were published in 1826. The first of these I demonstrated in 1935 is an absolute synonym of *Crabro* Fabricius, 1775,[44] and since Fabricius' name is a homonym of Geoffroy's earlier *Crabro*, the type genus of the present complex must henceforth be known as *Pemphilis* Risso. In 1935 I merely called attention to this situation and left it to the judgment of my fellow workers what course they might choose to follow. Two years later when I published my paper on the types of the Sphecoid generic names,[45] I still hesitated to make such a radical change. Now, however, I see no alternative but to do so and hereafter will use *Pemphilis* Risso, 1826 and Pemphilidini in the sense of *Crabro* Fabricius, 1775 and Crabronini, for the reasons set forth below.

For well over a century *Crabro* in the sense of Fabricius has been used in this complex of the Sphecoid wasps, but if Geoffroy's name is adopted, then the name is transferred from the Aculeates to the sawfly group which for an equally long period has been known as *Cimbex*. As a result of certain representations brought before them, the International Commission on Zoölogical Nomenclature, meeting at Lisbon in 1935 during the Twelfth International Zoölogical Congress, decided to suppress *Crabro* Geoffroy, 1762, and validate *Crabro* Fabricius, 1775 for the wasps, and *Cimbex* Olivier, 1790, for the sawfly genus, by placing both on the Official List of Generic Names.[46] But their action was ineffectual on at least two scores: first, the published attempt to do so was illegal and not in conformance with the Rules of Nomenclature which stipulate that intent to conserve or change a name must be published at least one year prior to such action; and secondly, it has since been shown by Ross[47] that the name *Clavellarius* Olivier, 1789 has priority over *Cimbex* Olivier, 1790, thus automatically removing both *Crabro* and *Cimbex* from the List. Thus to save these names, in what is purported to be their generally accustomed senses, will require one, if not several more petitions, decisions, and "opinions." Indeed, pleas ot such an effect are, I believe, either now before, or in process of being formulated for presentation to the Commis-

42 Rohwer: Psyche, XVIII, p. 154, (1911).

43 Risso: Hist. nat. Europ. merid., V, p. 227, (1826).

44 Pate: Ent. News, XLVI, pp. 245-246, (1935).

45 Pate: The Generic Names of the Sphecoid Wasps and their type species. Mem. Amer. Ent. Soc., no. 9, pp. 1-103, (1937).

46 C. R. XII Congr. Internat. Zool. (Lisbon, 1935), I, pp. 191-193, (1936).

47 Ross: Illinois Biol. Monograph., XV, no. 2, pp. 59-60, (1937).

sion.[48] But these petitions are merely futile temporal expedients. Moreover, as so frequently happens in such cases, they are made by powerful but quite unrepresentative provincial lobbyist groups whose knowledge and comprehension of the situation is lamentably inadequate. I do not believe in nomina conservanda, save perhaps in very exceptional or extraordinary circumstances. And certainly the case of *Crabro* Fabricius cannot be considered to fall in either of those categories. For there is little agreement in the literature in the application of *Crabro* to any particular group of these wasps: indeed, Lepeletier and Brullé's name *Thyreopus* is in far more common and constant use, and if a conservandum is presumably in order, it would be far more logical to make it for that name.

In adopting the course I now propose to follow, I fully realize I shall be subject to much criticism. But I am merely trying to do what my predecessors should have done long ago; what my contemporaries apparently now lack the courage to do: and that is to face the music instead of ruining another hundred and fifty or more years of literature by blindly accepting inaccurate statements and fiat decisions based too often upon incomplete research, as well as specious reasoning and an inadequate comprehension of the facts and fundamental principles involved.

EUPLILIS Risso

Euplilis Risso, Hist. Nat. Europ. Merid., V, p. 227, (1826). [Type: *Sphex clavipes* Linnaeus, 1758. Isogenotypic with *Rhopalum* Kirby, 1829, *Physoscelus* Lepeletier & Brullé, 1835, and *Physoscelis* Westwood, 1839, *q. v.*]

Rhopalum Kirby [in Stephens], Nomen. Brit. Insect, p. 34, (1829). [Type: *Sphex clavipes* Linnaeus, 1758.]

Corynopus Lepeletier & Brullé, Ann. Soc. Ent. France, III, p. 802, (1835). [Type: *Sphex coarctata* Scopoli, 1763. Isogenotypic with *Dryphus* Herrich-Schaeffer, 1840, *q. v.*]

Physoscelus Lepeletier & Brullé, Ann. Soc. Ent. France, III, p. 804, (1835). [Type: *Sphex clavipes* Linnaeus, 1758.]

Physoscelis Westwood, Introd. Mod. Class. Insects, II, Synops. Gener., p. 80, (June, 1839). [Type: *Sphex clavipes* Linnaeus, 1758.]

Dryphus (?) Herrich-Schaeffer, Nomencl. Ent., Zw. Hft., p. 123, (1840). [Type: *Sphex coarctata* Scopoli, 1763.]

Alliognathus Ashmead, Canad. Entom., XXXI, p. 219, (1899). [Type: *Crabro occidentalis* Fox, 1895.]

Three genera, *Euplilis, Podagritus* and *Moniaecera,* are differentiated from all other Pemphilid wasps by their three-segmented labial and five-segmented maxillary palpi, and their slender, elongate, petiolate abdomens. Hitherto all the forms possessing this distinctive combination of features were generally assigned to *Rhopalum,* i.e. *Euplilis,* but, as indicated in the foregoing analytical table to the genera, there is ample justification for considering *Podagritus* and *Moniacera* discrete generic entities.

The genus *Euplilis* is divisible into three subgenera: *Euplilis* in the

48 *Cf.*: The Generic Names of British Insects. Pt. 5: The Generic Names of the British Hymenoptera Aculeata, ... prepared by O. W. Richards. (1937).

restricted sense, of which *Rhopalum, Physoscelus* and *Physoscelis* are absolute synonyms; *Corynopus* Lepeletier & Brullé, with its recently discovered synonym *Dryphus* Herrich-Schaeffer; and *Alliognathus* Ashmead.

Distribution.—The present genus is a moderate sized complex of small forms, with representatives in all the major zoögeographic areas of the world.

Ethology.—The species of *Euplilis* are primarily rubicolous, nesting in brambles such as raspberry canes, or in the stems of currants, mallows and elder. Often, however, they construct their galleries in the rotten wood of logs and old stumps, and on occasion utilize pre-existing cavities like the abandoned holes of wood-boring beetles, cracks and crannies in old walls, or even the interior of straws for their nests. They provision their cells with small Diptera (Chironomidae, Mycetophilidae, Cecidomyidae, Chloropidae, etc.), Psocids or aphids.

MONIAECERA Ashmead

Moniaecera Ashmead, Canad. Entom., XXXI, p. 220, (1899). [Type: *Crabro abdominalis* Fox, 1895.]

The generic validity of *Moniaecera* has remaining unrecognized ever since Ashmead established it in 1899. However, as indicated in the key to genera, there are congeries of characters which entitle it to generic rank.

Distribution.—The genus *Moniaecera* is a small group of half a dozen or more species, confined largely if not wholly to Sonoran Nearctic America (Georgia to California), with its epicentre apparently in the southwestern United States.

Ethology.—According to Hartman,[49] *Moniaecera abdominale* constructs its burrows in sandy soil and provisions them with the Cicadellid *Kolla bifida* (Say).

PODAGRITUS Spinola

Podagritus Spinola [in Gay], Hist. fis. pol. Chile, Zool., VI, p. 353, (1851). [Type: *Podagritus Gayi* Spinola, 1851.]

The present group has usually been treated as a synonym, or at most but a subgenus of *Rhopalum*, i.e. *Euplilis*, but *Podagritus* is indubitably entitled to generic rank. The salient characteristics of *Podagritus* have been presented in the key to genera on a preceding page.

Subgenera.—The Neotropical species of *Podagritus* for the most part have the occipital carina more or less of a complete circle in extent, and the mesopleura with a sharply carinate epicnemium anteriorly on the prepectus. Moreover, the anterior portion of the lateral propodeal faces are furnished with another epicnemium for the reception of the hind legs; this propodeal epicnemium is usually delimited posteriorly by a more or less sharp keel or carina which descends obliquely from the propodeal spiracle. Furthermore,

49 Bull. Univ. Texas, no. 65, Sci. Ser. no. 6, p. 43, (July, 1905).

the marginal cell of the fore wing is generally obliquely truncate apically, and the mandibles are usually very indistinctly bidentate at apex.

Conversely, the Australian forms — incorrectly assigned hitherto to *Rhopalum*, i.e. *Euplilis* — have the prepectal epicnemium merely angulate, not sharply carinate anteriorly as in the Chilean species, and moreover show no trace of propodeal epicnemia. In addition, the occipital carina is quite incomplete, the mandibles are distinctly bidentate at apex, and the marginal cell of the fore wing is usually squarely truncate at apex. The Australian species evidently represent the more generalized stock of *Podagritus* and, when a revisional study of all the component forms is made, may prove separable as a distinct subgenus to which the name *Echuca* may be applied (Type: *Crabro tricolor* Smith, 1856).

Distribution.—The genus *Podagritus* is present in Australia and in the Neogaeic Realm, being particularly well developed in the Chilean province of the latter region.

Ethology. — The Chilean species of *Podagritus*, according to Claude-Joseph,[50] nest in dry or sandy soil and provision their burrows with various Diptera.

QUEXUA Pate

Quexua Pate, Rev. Entom. (Rio de Janeiro), XIII, p. 55, (1942). [Type: *Quexua (Quexua) cashibo* Pate, 1942.]

Arecuna Pate, Rev. Entom. (Rio de Janeiro), XIII, p. 58, (1942). [Type: *Quexua (Arecuna) essequibo* Pate, 1942.]

This distinctive little tropical American entity, which is divisible into two well marked subgenera: *Arecuna* and *Quexua*, has been recently described and reviewed elsewhere.[51]

Distribution.—The five known species of *Quexua* are confined to the tropical forest areas of the New World. The epicentre is apparently in the Amazonian basin of South America.

CROSSOCERUS Lepeletier & Brullé

Crossocerus Lepeletier & Brullé, Ann. Soc. Ent. France, III, p. 763, (1835). [Type: *Sphex palmipes* Linnaeus, 1767.]

Blepharipus Lepeletier & Brullé, Ann. Soc. Ent. France, III, p. 728, (1835). [Type: *Blepharipus nigrita* Lepeletier & Brullé, 1835.]

Cuphopterus A. Morawitz, Bull. Acad. Sci. St. Petersbourg, IX, p. 252, (1866). [Type: *Crabro (Blepharipus) monstrosus* Herrich-Schaeffer (in Dahlbom)].

Coelocrabro Thomson, Hymen. Scandinav., III, pp. 262, 264, (1874). [Type: *Crabro pubescens* Shuckard, 1837 (=? *Blepharipus nigrita* Lepeletier & Brullé, 1835).]

Hoplocrabro Thomson, Hymen. Scandinav., III, pp. 262, 277, (1874). [Type: *Crabro 4-maculatus* Fabricius, 1793.]

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50 Ann. Sci. Nat., Zool., (10), XI, pp. 69-77, (1928).

51 *Cf.:* Pate: On *Quexua*, a new genus of Pemphilidine Wasps from Tropical America. Rev. Entom. (Rio de Janeiro), XIII, pp. 54-75, (1942).

Epicrossocerus Ashmead, Canad. Entom., XXXI, p. 215, (1899). [Type: *Crabro insolens*, Fox, 1895.]

Stenocrabro Ashmead, Canad. Entom., XXXI, p. 216, (1899). [Type: *Crabro planipes* Fox, 1895.]

Dolichocrabro Ashmead, Canad. Entom., XXXI, p. 216, (1899). [Type: *Dolichocrabro Wickhamii* Ashmead, 1902.]

Synorhopalum Ashmead, Canad. Entom., XXXI, p. 218, (1899). [Type: *Crabro decorus* Fox, 1895.]

?Ischnolynthus Holmberg, An. Mus. Nac. Hist. Nat. Buenos Aires, (3), II, p. 472, (1902). [Type: *Ischnolynthus foveolatus* Holmberg, 1902.]

Ablepharipus Perkins, Trans. Ent. Soc. London, p. 390, (1913). [Type: *Crabro podagricus* Van der Linden, 1829.]

Acanthocrabro Perkins, Trans. Ent. Soc. London, p. 391, (1913). [Type: *Crabro vagabundus* Panzer, 1798.]

Yuchiha Pate, Lloydia, VI, p. 272 (1944). [Type: *Crossocerus (Yuchiha) xanthochilos* Pate, 1944.]

Apocrabro Pate, Lloydia, VI, p. 282 (1944). [Type: *Crossocerus (Apocrabro) aëta* Pate, 1944.]

Nothocrabro Pate, Lloydia, VI, p. 314 (1944). [Type: *Crabro nitidiventris* Fox, 1895.]

Stictoptila Pate, Lloydia, VI, p. 315 (1944). [Type: *Crabro confertus* Fox, 1895.]

The genus *Crossocerus* is rivalled in size and complexity in the Pemphilid wasps only by *Ectemnius*. The hundred or more species which comprise *Crossocerus* are extremely diverse in their structural features. Sixteen names have been proposed for entities for their reception, and of these the following dozen may be recognized as discrete and valid subgenera: *Crossocerus* in the restricted sense, of which *Stenocrabro* Ashmead may be considered a subordinate section; *Blepharipus* Lepeletier & Brullé, of which *Coelocrabro* is an absolute synonym; *Cuphopterus* Morawitz; *Hoplocrabro* Thompson; *Epicrossocerus* Ashmead; *Synorhopalum* Ashmead; *Ablepharipus* Perkins; *Acanthocrabro* Perkins; *Yuchicha* Pate; *Apocrabro* Pate; *Nothocrabro* Pate; and *Stictoptila* Pate. All these subgeneric entities of *Crossocerus* have been recently defined and reviewed.[52] As here understood, the genus *Crossocerus* is approximately equivalent to Kohl's "Artengruppe *Crossocerus*."[53]

Distribution.—The genus *Crossocerus* is predominantly Holarctic in distribution, but various subgenera have representatives in the Neotropical, Oriental and Ethiopian Regions. Turner has incorrectly referred a number of Australian species to this genus. So far as is known, no forms occur in the latter region.

Ethology.—The species of *Crossocerus* are either terricolous or xylicolous. Diptera are the usual prey of the majority of the species, but some forms provision their nests with Hemiptera, and a few occasionally resort to caddis flies, small moths, or even mayflies or sawflies. The ethology of the various subgenera has been fully discussed or indicated in a recent review of the genus.[52]

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52 *Cf.* Pate: The Subgenera of Crossocerus, with a Review of the Nearctic Species of the subgenus Blepharipus. Lloydia, VI, (1944).

53 Kohl: Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 193, (1913).

Piyuma[54] new genus

Crabro Turner [in part], Proc. Zool. Soc. London, 1908, p. 258, (1908).—Williams, Philippine Journ. Sci., XXXV, p. 100, (1928).

Crabro (Crossocerus) Turner, Ann. & Mag. Nat. Hist., (8), X, p. 63, (1912).

From all other members of the priscan Crossoceroid complex, *Piyuma* is readily distinguished by the structure of the abdomen, particularly the first segment which is subpetioliform, subnodose apically, and separated from the second segment by a rather strong constriction. Its nearest relative, albeit somewhat remote, is the Neogaeic entity *Taruma* with which it agrees in the relative position of the ocelli, the long anal lobe of the hind wing, and the incomplete occipital carina, but from which it may be distinguished, in addition to the shape of the abdomen, by the bicarinate antennal scapes, the bidentate mandibular apices, the absence of any indication of a marginate scapal sinus on the front, the rounded and ecarinate pronotum and mesosternum, and the immaculate black abdomen, as well as the distinctive conformation of the female pygidial area.

Generic Characters. — Moderately small, fulgid, finely punctate forms. Head subquadrate in anterior aspect, transversely subrectangular in dorsal aspect. Eyes naked, more coarsely facetted anteriorly than posteriorly; inner orbits very strongly convergent toward clypeus and antennal sockets. Malar space wanting. Front with upper portion flat and on same plane as vertex, not bisected by a carinule, abruptly rounded into the vertical aspect which is narrow, more or less concave between inner orbits but without a marginate scapal sinus. Vertex without supra-orbital foveae; ocelli rather large, arranged in a moderately high isosceles triangle which is broadest at base; temples moderate; occipital carina more or less well developed but not appreciably flanged, foveate, a complete circle in extent nor attaining the hypostomal carinule. Antennae distinctly thirteen-segmented in males and twelve-segmented in females, situated low on face on dorsal margin of clypeus, the sockets contiguous to each other and to nearest lower inner orbit; scapes straight, slender, elongate, subcylindrical, flat anteriorly and longitudinally bicarinate, *i.e* both inner and outer anterior margin with a sharp longitudinal carinule; pedicel subcylindrical, subequal in length to first flagellar article; flagellum simple, in males without excisions or expansions, but each article with a few inconspicuous erect hairs or setae beneath. Clypeus short; transverse, linear and flat laterally to flatly tectate discally, provided there with a sharp median longitudinal keel or carinule which terminates abruptly a short distance before the apical margin of the short, broad, weakly trilobed or tricrenulate median lobe. Mandibles stout; apices bifid in both sexes; lower margins entire; inner margins edentate. Females without a psammophore.

Thorax with pronotum short, transverse, situated on a level with the mesonotum, rounded and ecarinate dorsally and laterally, but hind margin strongly impressed. Mesonotum simple, with separated, moderate punctures throughout, mesonotal laminae not appreciably developed; axillae well devel-

54 After the Piyuma (*seu* Puyuma) of southeastern Formosa (Taiwan).

oped but immarginate laterally; suture mesonotum and scutellum, and scutellum and postscutellum deeply impressed but not foveolate. Mesopleura more or less fulgid; with fine, well separated punctures throughout; prepectus with a sharply carinate epicnemium anteriorly; a sharp vertical carina before middle coxae; episternal suture and hind margins of mesopleura and metapleura strongly foveolate; episternauli, mesopleurauli, hypersternauli, and sternauli all wanting; mesopleural pit large and distinct; mesosternum rounded, not transversely carinate anteriorly. Propodeum finely sculptured; dorsal face with an indistinctly delimited nitidous, trigonal area discally; lateral carinae present and well developed, simple and not bifurcate below; lateral faces more or less nitidous.

Fore legs simple in both sexes; neither tibiae, tarsi, nor femora appreciably dilated, expanded or flattened; trochanters normal, not elongate; females without a distinct pecten on fore tarsi. Middle and hind legs normal; middle tibiae subequal in length to femora in both sexes, and with a distinct apical calcar on middle and two on hind tibiae.

Fore wing with marginal cell more than twice as long as wide, broadly, squarely truncate at apex and with a distinct appendiculate cell, the transverse cubital vein straight, oblique, inclivous and received at basal third of radial vein, the first abscissa of which is one-half the length of second abscissa; recurrent vein received at middle of cubitus, the two abscissae of which are subequal in length. Hind wings with anal lobe subequal in length to the submedian cell.

Abdomen immaculate black; fulgid and finely punctate at most; sessile to subsessile, the first segment more or less subnodose at apex and separated from second by a strong constriction; remainder of abdomen fusiform in female, subclavate in male. Tergites with distinct basal acarid chambers, and folded under roundly and imbricate with the convex sternites; second sternite without a small, opaque, finely and closely punctate oval spot anteriolaterally on each side. Males without a pygidial area on ultimate tergite, the puncturation of which is not appreciably coarser than that of penult tergite; sternites simple, without tubercles or processes. Females with an opaque, finely coriaceous, broadly trigonal pygidial area which is somewhat narrowed apically and bisected by a longitudinal carinule, the lateral margins glabrous.

GENOTYPE: *Piyuma koxinga* new species.

Distribution.—The present genus is an Oriental and Australian entity. At present, I know two forms that are definitely referable to *Piyuma:* the Formosan *koxinga,* described below, and Turner's Australian species *prosopoides.*[55] The Philippine form, *Crabro makilingi,*[56] which Williams described from Luzon, is likewise in all probability a member of this genus.

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55 *Crabro prosopoides* Turner, Proc. Zool. Soc. London, 1908, p. 528, (May 12, 1908); [♀, ♂; QUEENSLAND: Mackay; Townsville].—*Crabro (Crossocerus) prosopoides* Turner, Ann. & Mag. Nat. Hist., (8), X, p. 63, (1912).

56 *Crabro makilingi* Williams, Philippine Journ. Sci., XXXV, p. 100, pl. 6, fig. 8, (1928); [♀; PHILIPPINE ISLANDS: Los Baños, Luzon].

Ethology.—In his interesting paper on the natural history of a Philippine nipa house, Williams states that at Los Baños on Luzon he found the species *makilingi* nesting in deserted termite tunnels in a bamboo upright forming a house support.[57] From the absence of a psammophore and of a pecten on the fore tarsi of the females, I infer the biology of both *koxinga* and *prosopoides* is probably quite similar to that of *makilingi*.

Piyuma koxinga[58] new species

The present Formosan species is most closely related to Turner's Queensland form *prosopoides*. But in that species the antennal scapes, the entire pronotum, scutellum and postscutellum, and the greater part of the legs are deep, bright yellow; the head, thorax, and abdomen are quite closely and relatively coarsely punctate, while the metapleura and lateral faces of the propodeum are more or less horizontally striate; moreover, the posterior face of the propodeum, as well as the lateral areas of the dorsal surface, are distinctly striatopunctate, and the dorsal trigonal enclosure is radiately striate at base. In *koxinga*, however, the scapes, postscutellum and legs are dark; the somatic puncturation much finer and more sparse; the metapleura and lateral faces of the propodeum nitidous, or at most with very sparse acupuncturation like the posterior face of the propodeum, while the dorsal enclosure is very poorly delimited and completely nitidous.

Type. — ♂; Taihorinsho (Tairin), Tainan-Shyu, Formosa. Elevation, about 100 meters. September, 1909.

Male.—6 mm. long. Black; fulgid; the following deep stramineous; pronotum with a transverse fascia dorsally, pronotal tubercles, and anterior half of scutellum. Sordid castaneous: antennal scapes, pedicel and flagellum beneath, fore tarsi, tibial calcaria, and axillary sclerites. Scapes posteriorly, flagellum above, and middle and hind tarsi, light brunneous. Palpi sordid luteous. Wings hyaline, slightly tinted with fuscous; veins and stigma dark castaneous.

Head subfulgid; clypeus with an appressed, sericeous, silvery pile; front and vertex more sparsely clad with short, erect, inconspicuous dark aeneous puberulent pubescence; temples with a thin clothing of decumbent silvery hair above, becoming thicker, longer and erect below. Front flat, glabrous, subitidous, without a distinct scapal sinus; vertex with fine, evenly disposed, moderately close setigerous punctures; supra-orbital foveae absent; ocelli situated in a moderately high isosceles triangle which is broadest at base; ocellocular line three-fourths the postocellar distance; temples fulgid, with puncturation similar to, but somewhat more sparse than, that on vertex; occipital carina distinct but neither flanged, foveolate, a complete circle in extent, nor attaining the hypostomal carinule. Antennae short, reaching about to occiput; scapes straight, subcylindrical, flat anteriorly and longitudinally bicarinate,

57 Philippine Journ. Sci., XXXV, p. 85, (1928).

58 After Koxinga (Chêng Kung) who in 1662 established the Kingdom of Formosa, last outpost of the Ming dynasty.

one-half the vertical eye length; pedicel subcylindrical, twice the length of the first flagellar article; flagellum simple, finely puberulent, first segment short, two-thirds the length of second, ultimate article subequal in length to two preceding segments combined, and somewhat compressed, keeled beneath and roundly truncate at apex, all segments with an erect preapical seta beneath, the sixth to tenth articles nitidous and somewhat flattened to slightly concave beneath and with the apices slightly produced. Clypeus transversely subhexagonal, with the lateral portions attenuate and flat; median length one-fourth the vertical eye length; flatly tectate discally and bisected by a sharp, longitudinal carinule which terminates abruptly a short distance before the apex; produced medially into a short broad lobe, the apical margin of which is tricrenulate and laterally with a dentiform angle separated from median tricrenulate portion by a rather long and shallow emargination. Mandibles bidentate at apex; lower margins entire.

Thorax fulgid; clothed dorsally with a thin vestiture of short, erect, light aeneous hair, pleura and sterna more sparsely clad with decumbent silvery hair. Pronotum short, transverse, sparsely and finely punctate; anterior dorsal margin rounded, ecarinate, the lateral angles rounded, the posterior margin deeply, abruptly, transversely impressed. Mesonotum with fine, separated, setigerous punctures throughout; sutures between mesonotum and scutellum and scutellum and postscutellum deeply impressed but efoveate; axillae moderate, lateral edges weakly angulate posteriorly; scutellum flatly tumid, punctured like mesonotum; postscutellum simple, punctate like scutellum. Mesonotum perfulgid; finely but somewhat more sparsely punctate than mesonotum; anteriorly with a sharp epicnemium; omauli efoveate, but episternal suture, vertical carina before middle coxae, and posterior margin strongly foveate; mesopleural pit large, distinct, strongly impressed; metapleura perfulgid, with sparse, fine acupuncturation, hind margin foveolate; mesosternum rounded anteriorly. Propodeum fulgid; with a thin vestiture of suberect, inconspicuous, light hair on dorsal and posterior faces; dorsal face discally with a glabrous, nitidous, trigonal area which is not delimited by furrows or foveolae, the anterior margin transversely foveolate, bisected by a fine longitudinal carinule which is obsolescent posteriorly, lateral areas of dorsal face finely, sparsely acupunctate; posterior face finely, sparsely acupunctate throughout, bisected on lower half by a vertical carinule, and on upper half by a deep, immarginate furrow, laterad of which the surface is traversed by a few fine, horizontal, subparallel carinulae; lateral carinae present, well developed for their entire length, and simple below; lateral faces glabrous, and nitidous save for a few minute acupunctures.

Legs simple; fore tarsi not appreciably flattened. Middle tibiae not spinose on outer faces, apically with a distinct calcar. Hind coxae simple; hind femora with rather long, erect white hair beneath, and obliquely flattened below but without a trenchant edge lengthwise; hind tibiae moderately spinose on outer faces, with two apical calcaria, the longer subcultriform and six-tenths the length of hind metatarsi.

Abdomen fulgid; tergites with fine, evenly disposed acupunctures through-

out, each bearing a rather long, decumbent aeneous hair; sternites perfulgid, the first three more sparsely punctate and pubescent than the remainder. First segment subnodose apically; a strong constriction between first and second segments; second to sixth tergites inclusive with well developed basal acarid chambers; ultimate tergite without a pygidial area, the lateral margins not appreciably inflexed below, and the disc not more coarsely punctate than the sixth tergite. All sternites simple, seventh without processes or tubercles, caudal margin of sixth very broadly and shallowly excavate, of seventh truncate; hypopygium flat, elongate, subrectangular, the apical margin roundly truncate and with six elongate bristles.

Allotype.—♀; Taihorinsho (Tairin), Tainan-Shyu, Formosa. Elevation, about 100 meters. May, 1909.

Female.—6 mm. long. Similar to the male (type) except as follows:

Black; the following stramineous: pronotum, tubercles, scutellum, fore and middle tibiae with an elongate spot outwardly at base, hind tibiae annulate at base, and middle and hind metatarsi. Otherwise livery as in male.

Head in general the same as male but scape nine-sixteenths (.5625) the vertical eye length; pedicel four-thirds the length of first flagellar article; flagellum simple, finely puberulent, the first segment three-fifths the length of second, ultimate article subequal in length to two preceding segments combined.

Thorax generally the same as male but the puncturation of mesonotum somewhat finer and closer.

Fore tarsi without a distinct pecten.

Abdomen as in male; but ultimate tergite with a glabrous trigonal pygidial area, the lateral margins rather strongly narrowed toward apex but not furnished with any erect bristles, the disc subopaque, very finely coriaceous and bisected by a nitidous longitudinal carina.

Specimens examined.—14; 8 males, 6 females, as follows:

FORMOSA: Taihorinsho (Tairin), Tainan-Shyu; elevation about 100 meters; April: 2 ♂; May: 3 ♂; November, 1909: 1 ♀, 1 ♂. Tainan, Tainan-Shyu; July 22, 1911: 1 ♂. Kankau (Koshun), Takao-Shyu; elevation 10 meters; June, 1912: 5 ♀, 1 ♂.

The paratypes agree with the typical pair in all essential features of livery and structural detail.

Taruma[59] new genus

Superficially *Taruma* resembles *Piyuma* in many respects, but unlike that Oriental entity the abdomen of the present genus is distinctly maculated with yellow, and, moreover, has no constriction between the first and second segments. Furthermore, the antennal scapes of *Taruma* are only unicarinate, and the mesosternum and dorsal face of the pronotum are sharply carinate anteri-

59 After the Taruma Indians of British Guiana.

orly, while the females have the mandibles tridentate at apex and the pygidium subnitidous and not bisected by a longitudinal carinule.

Generic Characters.—Moderately small, perfulgid, finely punctate forms. Head subquadrate in anterior aspect, transversely subrectangular in dorsal aspect. Eyes naked, more coarsely facetted anteriorly than posteriorly; inner orbits very strongly convergent toward clypeus and antennal sockets. Malar space wanting. Ocelli rather large, arranged in a broad, moderately high isosceles triangle. Temples moderate; occipital carina rather well developed, weakly flanged and foveate but not a complete circle in extent nor attaining the hypostomal carinule. Antennae situated low on face on dorsal margin of clypeus, the sockets contiguous to each other and to nearest lower inner orbit; twelve-segmented in females, and probably thirteen-segmented in males; scapes straight, slender, elongate, slightly flattened anteriorly and longitudinally unicarinate; pedicel subcylindrical, subequal in length to first flagellar article; flagellum simple. Front with upper portion flat and on same plane as vertex, bisected by a shallow furrow which runs forward from anterior ocellus and in which lies a very fine, barely perceptible, longitudinal carinule, the anterior vertical aspect of front with a glabrous, nitidous, concave scapal sinus which is very weakly margined laterally but immarginate dorsally. Vertex simple, without supra-orbital foveae. Clypeus short; transverse and linear laterally to flatly tectate discally, produced medially into a short, narrow, subtruncate lobe. Maxillary palpi with six, labial palpi with four segments. Mandibles stout; apices trifid in females; lower margins entire. Females without a psammophore.

Thorax with pronotum short, transverse, situated about on a level with the mesonotum, and with dorsal surface sharply carinate anteriorly, the lateral angles acute, and posterior margin moderately impressed. Mesonotum simple, with separated, moderate, setigerous punctures throughout; axillae well developed; suture between mesonotum and scutellum, and scutellum and postscutellum deeply impressed and distinctly foveate. Mesopleura perfulgid; with fine well separated punctures throughout; anteriorly with a sharply carinate epicnemium which is continuous ventrally with the sharply carinate anterior margin of the mesosternum; a sharp vertical carina before middle coxae; episternal suture vertical or almost so from below tegulae; episternauli, mesopleurauli, hypersternauli, and sternauli all wanting; mesopleural pit large and distinct. Propodeum with but little sculpture; dorsal face with a nitidous, semicircular area delimited on disc by a strongly foveate groove; posterior face bisected by an immarginate groove or furrow; lateral carinae present and well developed, simple and not bifurcate below; lateral faces more or less nitidous.

Fore legs simple; females with fore tarsi slightly flattened and with a weak pecten. Middle and hind legs normal; middle tibiae subequal in length to femora, and with a distinct apical calcar on middle, and two calcaria on hind tibiae.

Fore wing with marginal cell three times as long as wide, broadly and squarely truncate at apex and with a distinct appendiculate cell; radial vein

with first abscissa less than one-half (.44) the length of second abscissa; transverse cubital vein straight, oblique, inclivous, three-fifths the length of second abscissa of cubitus which is subequal in length to first abscissa of cubitus. Hind wing with anal lobe slightly surpassing the short submedian cell in length.

Abdomen black with yellow maculations; impunctate or very finely punctate at most; fusiform, the first segment perfectly sessile with the second, no strong constriction between them. Tergites with basal acarid chambers, and folded under roundly and imbricate with the convex sternites; second sternite with a small, opaque, finely and closely punctate oval spot anteriolaterally on each side. Females with a subnitidous, elongate trigonal pygidial area somewhat narrowed apically, but not bisected by a longitudinal carina, the lateral margins furnished with a few short, erect, aeneous setulae.

GENOTYPE: *Taruma bara* new species.

The genus *Taruma* has been erected for the reception of the following distinctive and peculiar South American form.

Taruma bara[60] new species

The distinguishing features given for the genus will likewise serve to differentiate *bara* from all other Neotropical Pemphilid wasps.

Type. — ♀. In Colony House, in Clearing, Mazaruni, British Guiana. September 14, 1937, (O. W. Richards and John Smart.) [British Museum (Natural History).]

Female. — 5 mm. long. Fulgid black; the following deep stramineous: palpi, basal half of mandibles (apices red), scapes, pedicel, pronotum dorsally to and including the tubercles, prepectus with a large spot, axillary sclerites with a discal spot, axillae, scutellum with a rather large spot laterally on each side, postscutellum entirely, middle and hind coxae at apex, all trochanters, fore and hind femora above on apical half, middle femora largely, fore tibiae entirely, and middle and hind tibiae on outer faces, all tarsi, and abdomen with a large ovate spot on each side of second, third and fourth tergites. Pedicel and flagellum light brunneous above, light fulvous beneath. Wings clear hyaline, iridescent; veins and stigma light brunneous.

Head subquadrate in anterior aspect, broadly subrectangular in dorsal aspect; clypeus with a dense, appressed, silvery sericeous pile; vertex and upper portion of front with a thin inconspicuous vestiture of short suberect hair; temples similarly clothed with decumbent silvery hair. Front on anterior vertical aspect between lower inner orbits with a shallow, concave, glabrous and nitidous basin which is very weakly marginate laterally but immarginate above; upper horizontal portion flat, on same plane as vertex, and with fine well separated setigerous acupunctures, and running forward from median ocellus bisected by a shallow impression in which lies a very fine carinule.

60 After the Bara Indians of the Guianas.

Vertex punctate like front; supra-orbital foveae not evident; ocelli rather large, arranged in a broad, moderately high, isosceles triangle, postocellar line eight-tenths the ocellocular distance; temples moderately developed; occipital carina well developed but not a complete circle in extent nor attaining hypostomal carinule, somewhat flanged and inconspicuously foveolate below and laterally; oral fossa campanulate; hypostomal carinule distinct but not flanged nor foveolate. Antennae with scapes slender, subcylindrical, unicarinate, six-tenths the vertical eye length; pedicel subcylindrical, four-fifths the length of first flagellar article; flagellum simple, finely puberulent, first segment one and two-thirds the length of second, ultimate article simple, terete, one and a half times length of penult segment. Clypeus low subtrigonal in outline; median length about one-fourth (.233) the vertical eye length; flat and attenuate laterally to tectate discally where it is bisected by a longitudinal keel; produced medially into a short broad truncate lobe, the apical width of which is seven-tenths the median clypeal length, the lateral margins of lobe oblique and inconspicuously bicrenulate. Mandibles stout; tridentate at apex; lower margins entire. Psammophore absent.

Thorax in dorsal aspect distinctly narrower than (but four-fifths the width of) head; dorsally with an inconspicuous vestiture of very short, suberect, light aeneous hair; pleura with a thin clothing of longer decumbent silvery pubescence. Pronotum short, transverse, situated about on a level with the lightly arched mesonotum, and strongly, transversely carinate anteriorly to and including the tubercles, the lateral angles acutely dentate, weakly notched medially, dorsal surface transversely, posterior margin strongly, impressed. Mesonotum simple, with fine, separated, setigerous punctures throughout, posterior angles with small, moderate laminae; axillae moderate in size, lateral margins broadly rounded; scutellum flatly tumid, with scattered acupunctures, anterior margin coarsely foveate, posterior margin finely foveolate; postscutellum simple. Mesopleura with fine, well separated, setigerous acupunctures throughout; anteriorly with a sharply carinate epicnemium which is continuous ventrally with the sharply, transversely carinate mesosternum; a sharp vertical carina before middle coxae; omauli, the straight oblique episternal suture, and posterior margin strongly foveate; mesopleural pit distinct; metapleura glabrous, nitidous, hind margin coarsely foveate. Propodeum with a very thin vestiture of short, suberect, puberulent silvery hair on dorsal and posterior faces; dorsal face with a large semicircular enclosure delimited by a weakly foveolate shallow impression, and bisected by a fine longitudinal carinule, laterad of which the surface is perfulgid and without sculpture; posterior face bisected by an immarginate vertical furrow, the lateral areas perfulgid and without sculpture; lateral carinae present, well developed for their entire length and simple below; lateral faces glabrous and nitidous.

Legs simple, stout, unmodified. Tarsi with last segment more or less inflated, the claws simple and large, the pulvilli distinct; metatarsi subequal in length to three following segments combined; fore metatarsi slightly flattened beneath, and with a weak pecten of short stiff setulae. Middle and hind tibiae moderately spinose on outer faces; middle tibiae with one apical calcar; hind

tibiae with two calcaria, the larger one elongate-subcultriform and two-thirds the length of hind metatarsi.

Fore wing with marginal cell three times as long as wide, broadly, squarely truncate at apex; radial vein with first abscissa five-ninths (.45) the length of second abscissa; transverse cubital vein straight, oblique, inclivous, three-fifths the length of second abscissa of cubitus which is subequal in length to first abscissa of cubitus. Hind wing with anal lobe large, well separated off, and slightly surpassing the apex of the submedian cell.

Abdomen sessile, subfusiform; perfulgid, with fine, well separated, setigerous acupuncturation throughout; tergites with a very thin vestiture of short, decumbent, silvery to aeneous hair. Second to penult tergites with basal acarid chambers. Ultimate tergite with an elongate trigonal pygidial area which is somewhat narrowed and excavate apically, the lateral margins with a few bristles, the disc glabrous and nitidous save for a few scattered coarse punctures at base. Sternites subnitidous and subglabrous save for transverse preapical rows of erect setulae.

Only the unique female of this little Guianan species is known.

Paë[61] new genus

The present genus is a discrete entity somewhat intermediate between *Chimila* and *Foxita*. Like the latter, *Paë* has the occipital carina very well developed, strongly flanged, and a complete circle in extent; the pronotum and mesosternum sharply margined anteriorly; and the mesopleura furnished with hypersternauli. But unlike that genus, *Paë* lacks a strongly marginate scapal sinus, as well as a carinule bisecting the upper front; furthermore, the mesopleura are more or less opaque and horizontally costulate rather than fulgid and simply punctate, and moreover, in addition to the well developed hypersternauli, are unique in possessing another pair of foveolate furrows, the mesopleurauli, which are situated above and parallel to the hypersternauli. Finally, the anal lobe of the hind wing of *Paë* is short and but half the length of the submedian cell, whereas in *Foxita* the submedian cell and anal lobe are subequal in length. The differential characters separating *Paë* from *Chimila* have been presented in the introductory discussion of that genus.

Generic Characters.—Moderate sized, finely and closely punctate, fulgid to subopaque forms. Head broadly subrectangular in dorsal and anterior aspects; subquadrate in lateral aspect due to the well developed and somewhat swollen temples. Eyes naked, much more coarsely facetted anteriorly than posteriorly; inner orbits very strongly convergent toward clypeus and antennal sockets. Malar space wanting. Front with upper portion flat and on same plane as vertex but not bisected by a carinule, the anterior vertical aspect narrow, concave, but without a marginate scapal sinus. Vertex simple, without supra-orbital foveae; ocelli rather large, situated in a low isosceles triangle tending toward a curved line; occipital carina very well developed, flanged

61 After the Paë (*seu* Paës, Paëz, *sive* Paësez) Indians of the central cordillera of Colombia.

and more or less foveolate, a complete circle in extent and separated on mid-ventral line of head from the hypostomal carinule bordering the subquadrate to subrectangular oral fossa; hypostomal carinule well developed in the form of a strong rolled margin or edge, and from middle of its lateral margins with a weak carina passing laterad at right angles, then curving forward and terminating in the apex of the inframandibular lobe. Antennae twelve-segmented in females, (and probably thirteen-segmented in males), situated low on face on dorsal margin of clypeus, the sockets contiguous to each other and to nearest lower inner orbit; scapes straight, subcylindrical, flat anteriorly and longitudinally bicarinate, *i.e.* both inner and outer anterior lateral margin with a sharp longitudinal carinule; pedicel obterete, shorter than first flagellar article; flagellum simple. Clypeus short and arcuately linear laterally, median lobe with a broad transverse, concave, subopaque bevel which is sharply margined dorsally and provided medially with a more or less nasutiform porrect process. Maxillary palpi with six, labial palpi with four segments. Mandibles stout, the apices bifid; lower margins entire; inner margins with two successive arcuate preapical excisions thus producing two obtuse preapical dentiform angles, and in addition on basal half with a large and strong acute tooth. Females without a psammophore.

Thorax with pronotum short, transverse, situated on a level with the mesonotum, sharply and transversely carinate anteriorly to and including the tubercles, posterior margin deeply impressed. Mesonotum subopaque; coriaceous to finely striatopunctate; broadly, shallowly concave discally; laterally with well developed laminae more or less overlying bases of tegulae and separated from rest of mesonotum by a rather strong and foveolate groove; axillae large, subovate, dorsal surface weakly concave, lateral edges with more or less distinct reflexed margins; scutellum and postscutellum simple. Mesopleura subfulgid to opaque; with parallel horizontal striae or costulae; anteriorly with a sharply margined epicnemium which is continuous ventrally with the sharp and transversely margined mesosternum; a sharp (indistinct in some species) vertical carina before middle coxae; omauli and episternal suture present and foveolate; episternauli and sternauli absent; mesopleural pit small but distinct; hypersternauli present, well developed for entire length and foveolate; a short horizontal and foveolate groove, the mesopleuraulus, present above and parallel to each hypersternaulus. Propodeum with a large and well defined semicircular area traversed by costulae radiating from anterior on dorsal face; posterior face with a subcuneate discal impression; lateral carinae present, well developed for entire length and simple below.

Legs simple. Fore tarsi not appreciably flattened nor with a distinct pecten in females. All tarsi with the last segment more or less inflated, the claws large and normal, the pulvilli large. Middle tibiae with one apical calcar; hind tibiae with two calcaria, and the outer posterior face with a broad shallow sulcus running lengthwise, the inner surface with a dense vestiture of short velvety pile.

Fore wing with marginal cell four times as long as wide and broadly obliquely truncate at apex; radial vein with the first abscissa one-half to three-

fifths the length of the second abscissa; transverse cubital vein straight, oblique, inclivous, and one-half the length of second abscissa of cubitus which is six- to seven-tenths the length of first abscissa of cubitus. Hind wing with the anal lobe small, cuneate, distinctly separated off, and about one-half the length of the submedian cell.

Abdomen sessile; more or less fusiform; impunctate to finely punctate; third to fifth tergite inclusive with basal acarid chambers; second and third tergites with a more or less distinct strangulation on basal half. Females with a distinct pygidial area which is very strong narrowed apically, the lateral margins of pygidial area glabrous.

GENOTYPE: *Paë paniquita* new species.

As yet, only the female sex of *Paë* is known. The males, however, when discovered, will doubtless agree with the foregoing diagnosis. Moreover, their antennae will probably be found to be thirteen-segmented with the flagellar articles relatively simple; the middle tibiae be furnished with an apical calcar; the abdomen lack a distinct pygidial area on the ultimate tergite; and the mandibles exhibit essentially the same peculiar conformation displayed by the females.

Distribution.—The genus *Paë* is a Neotropical entity apparently confined, at least in great measure, to the tropical forest areas of northern South America. Two species, which are referable to it, are described herewith: the Colombian *paniquita,* and the Guianan *amaripa.*

Paë paniquita[62] new species

The shorter, somewhat differently formed clypeal lobe, the relatively shorter antennal scapes, the subequal postocellar and ocellocular distances, the strongly produced, subangulate hind angles of the hypostomal carinule, as well as the more extensive yellow livery, readily differentiate the present Colombian form *paniquita* from the following Guianan species *amaripa.*

Type. — ♀; Muzo, Department of Boyaca, Colombia. Elevation, 900 meters. July, 1936. (Joseph C. Bequaert.) [Museum of Comparative Zoölogy.]

Female.—8 mm. long. Black; the following deep stramineous; mandibles except red apices, pronotum dorsally, pronotal tubercles, axillae, scutellum with a small spot at each anterior lateral angle, postscutellum, fore and middle femora beneath and posteriorly, hind femora with a small apical spot on anterior faces, fore and middle tibiae on anterior and outer faces, hind tibiae with a broad transverse preapical band, and abdomen: second tergite with a large, broad, transverse, irregular spot laterally on each side, third and fourth tergite with broad basal fasciae which are constricted medially, fifth tergite entirely save for a small brunneous spot on disc, sixth tergite laterally, third sternite on anterior half, fourth sternite with a narrow median

62 After the Paniquita Indians of Colombia.

fascia interrupted medially and a small irregular preapical spot medially. Fulvous: palpi, pedicel, flagellum, tegulae, fore and middle tibiae exclusive of yellow markings, all tarsi, abdominal venter, and pygidium. Wings clear hyaline, iridescent; veins and stigma brunneous.

Head broadly subrectangular in anterior and dorsal aspect, subquadrate in lateral aspect; more or less fulgid. Clypeus, except disc, and front between inner orbits with dense appressed silvery sericeous pile; vertex and temples with a thinner and more inconspicuous vestiture of aeneous to silvery puberulent pubescence. Eyes much more coarsely facetted anteriorly than posteriorly; naked.[63] Front between inner orbits very narrow, concave, without any distinct scapal basin; upper horizontal portion of front on same plane as vertex, both flat and with fine, close setigerous acupuncturation throughout; supraorbital foveae absent or very indistinct; ocelli arranged in a low triangle tending toward a curved line, the postocellar and ocellocular distances subequal; temples very well developed, ecarinate, but somewhat inflated a short distance behind posterior orbits; occipital carina very well developed, flanged, more or less strongly foveolate and a complete circle in extent, sharply angulate laterally above, roundly angulate laterally below, well separated on midventral line of head from hypostomal carinule bordering the subquadrate oral fossa; hypostomal carinule developed into a strong rolled margin which at hind angles is produced into a rather prominent downcurved obtuse dentoid angulation; from middle of lateral margins of hypostomal carinule a weak carina passes laterad at right angles, then curves forward and terminates in the apex of the inframandibular lobe. Antennae with the scapes two-thirds the vertical eye length, straight, subcylindrical, flat anteriorly and strongly bicarinate; pedicel obterete, five-eighths the length of first flagellar article; flagellum simple, finely puberulent, second segment seven-eighths the length of first segment, ultimate article simple, terete, subequal in length to the two preceding segments combined. Clypeus flat and arcuately linear laterally, median length almost a fifth (.171) the vertical eye length, the median lobe transversely oval, concave, glabrous, impunctate, subfulgid, and transversely striate, the dorsal edge sharply margined and armed with a large depressed, porrect dentoid process medially, the apical margin trisinuate and strongly bidentate. Mandibles large, stout, apices bifid; lower margins entire; inner margins with a preapical tooth, basad of which is another dentoid process formed by the arcuate margin, the basal half armed with a large acute tooth. Psammophore absent.

Thorax subfulgid to fulgid; dorsally with a thin and inconspicuous vestiture of short, erect, aeneous puberulent hair; pleura and sterna with a similar but more noticeable clothing of silvery pubescence. Pronotum transverse, situated slightly below the level of mesonotum, the anterior dorsal margin very sharply, transversely carinate to and including tubercles, the lateral angles rounded, deeply notched medially, posterior margin strongly impressed. Mesonotum subopaque; very finely, closely striatopunctate throughout, the striations oblique to transverse anteriolaterally, curving around on disc and becoming longitudinal posteriorly; anterior half bisected by a fine longitudinal line,

63 Very finely and sparsely puberulent under magnification of 120 diam.

parallel to which on each side is a sharp carinule, the surface broadly, shallowly concave between the lateral carinules; mesonotal laminae well developed and sharply defined mesad by a foveolate impression; axillae large, subovate, dorsal surface weakly concave, lateral edges with an indistinct reflexed margin; suture between mesonotum and scutellum simple but strongly impressed; scutellum flatly tumid, finely longitudinally striatopunctate, posterior margin foveolate; postscutellum simple, finely punctate. Mesopleura more or less fulgid; finely punctate; prepectus and upper portion of pleura traversed by sharp, subhorizontal, parallel rugulae; anteriorly with a sharp epicnemium which is continuous ventrally with the sharp and transversely margined anterior edge of the mesosternum; episternauli and sternauli wanting; omauli and the straight oblique episternal suture strongly foveate; hypersternauli present, well developed for their entire length, and strongly foveate, parallel to and between them and the small but distinct mesopleural pit is another short, strongly foveolate furrow (the mesopleurauli); a sharp vertical carina before middle coxae; hind margin strongly foveolate; metapleura subfulgid, finely puberulent, traversed by parallel horizontal rugulae, hind margin foveolate. Propodeum subfulgid; with an inconspicuous vestiture of short, suberect, aeneous to silvery puberulent hair; dorsal face with a large subsemicircular enclosure defined by a strongly foveolate groove, bisected by a narrow, strongly marginate furrow and traversed by a series of strong carinules radiating from the anterior margin, the areas between the carinules finely and somewhat irregularly striatopunctate; posterior face with a broad, obcuneate and inconspicuously margined discal impression which is opaque and more or less scabrous within, the lateral surfaces finely striate above, the lower half traversed by three or four parallel horizontal carinules; lateral carinae present for entire length, simple below; lateral faces fulgid, horizontally aciculate.

Legs stout, relatively simple. Tarsi with last segment large, strongly inflated; claws normal; pulvilli large and distinct; fore tarsi not flattened or otherwise modified, without a distinct pecten. Middle tibiae moderately spinose on outer faces, and with a distinct apical calcar. Hind tibiae moderately to strongly spinose on outer faces, the outer posterior face with a strong but shallow groove running for almost entire length of tibiae, the inner faces furnished with a thick pile of short aeneous velvety pubescence, and apically with two acuminate calcaria, the longer almost three-fifths (.583) the length of hind metatarsi.

Fore wing with the marginal cell four times as long as wide, broadly and obliquely truncate at apex; radial vein with first abscissa almost three-fifths (.59) the length of second abscissa; transverse cubital vein straight, oblique, inclivous, one-half the length of second abscissa of cubitus which in turn is but seven-tenths the length of first abscissa of cubitus. Hind wing with the anal lobe small, cuneate, distinctly separated off, and but one-half the length of submedian cell.

Abdomen sessile, subfusiform. Tergites with a thin and inconspicuous vestiture of short decumbent, light aeneous puberulent hair; second and third tergites with a moderately strong subbasal strangulation, third to fifth tergites

inclusive with basal acarid chambers; ultimate tergite with a trigonal pygidial area which is more or less excavate and very strongly narrowed apically. Sternites nitidous and practically glabrous save for a transverse preapical row of erect setulae.

Male.—Unknown.

This interesting species is known only from the unique female described above.

Paë amaripa[64] new species

Although resembling the preceding species so closely that it may be easily confused with it, *amaripa* differs from *paniquita* in the relatively longer clypeus and antennal scapes and the much less extensively maculated abdomen and thorax. Furthermore, in *paniquita* the postocellar distance is subequal in length to the ocellocular line, whereas in *amaripa* the postocellar line is but three-fourths the ocellocular distance.

Type. — ♀. In High Forest, on Tukeit Trail along Potaro River at Kaietur Falls, British Guiana. September 9, 1937. (O. W. Richards & J. Smart.) [British Museum (Natural History).]

Female.—8 mm. long. Black; the following stramineous: palpi, mandibles except for red apices, scapes, pronotum along anterior dorsal margin, pronotal tubercles, axillae, a narrow line along anterior margin of postscutellum, fore and middle femora with a line beneath, fore tibiae on outer faces, middle and hind tibiae with a large preapical spot on outer faces, all tarsi, and on abdomen: second tergite with a narrow longitudinal line along sides, and the third, fourth and fifth tergites with a broad, transverse, trigonal macula laterally on each side. Fulvous: fore tibiae on inner faces, and pedicel and flagellum. Tegulae and axillary sclerites bruneous. Wings clear hyaline, iridescent; veins and stigma brunneous.

Head broadly subrectangular in anterior and dorsal aspect, subquadrate in lateral aspect; fulgid to subopaque. Clypeus, except disc, and front between inner orbits with dense appressed silvery sericeous pile; vertex and temples with a thinner, more inconspicuous vestiture of aeneous to silvery puberulent pubescence. Eyes naked, much more coarsely faceted anteriorly than posteriorly. Front between inner orbits very narrow, concave, without any distinct scapal basin; upper horizontal portion of front on same plane as vertex, both flat and with fine, close, setigerous acupunctures throughout; supra-orbital foveae absent; ocelli situated in a low isosceles triangle tending toward a curved line, the postocellar line about three-fourths (.76) the ocellocular distance; temples very well developed, ecarinate, but somewhat inflated a short distance behind posterior orbits; occipital carina very well developed, flanged, more or less strongly foveolate and a complete circle in extent, sharply angulate laterally above, roundly angulate laterally below, well separated on midventral line of head from hypostomal carinule bordering the subquadrate oral

64 After the Amaripa Indians of the Guianas.

fossa; hypostomal carinule developed into a strong rolled margin but not produced at hind angles into a rather prominent downcurved obtuse dentoid angulation as in *paniquita;* from middle of lateral margins of hypostomal carinule with a weak transverse carina as in *paniquita.* Antennae with the scapes about three-fourths (.76) the vertical eye length, straight, subcylindrical, flat anteriorly and strongly bicarinate; pedicel obterete, five-sevenths the length of first flagellar article; flagellum simple, finely puberulent, second segment six-sevenths the length of first segment, ultimate article simple, terete, three-fourths the length of two preceding segments combined. Clypeus flat and arcuately linear laterally, median length almost a fourth (.235) the vertical eye length, the median lobe with a wide, transverse, concave, glabrous, impunctate, subfulgid, and transversely striate bevel, the dorsal edge of which is sharply margined and produced medially into a large depressed, porrect to downcurved nasutiform dentoid process, the apical margin truncate and elliptically excised medially. Mandibles large, stout, apices bifid; lower margins entire; inner margins with a preapical tooth, basad of which is another dentoid process formed by the arcuately excised margin, the basal half armed with a large acute tooth. Psammophore absent.

Thorax opaque to subfulgid; dorsally with a thin and inconspicuous vestiture of short, erect, aeneous puberulent hair; pleura and sterna with a similar but more noticeable clothing of silvery pubescence. Pronotum transverse, situated slightly below level of mesonotum, the anterior dorsal margin very sharply, transversely carinate to and including the tubercles, deeply notched medially, lateral angles subacute, posterior margin strongly impressed. Mesonotum subopaque; coriaceous to very finely and indistinctly, closely striatopunctate throughout, the striations similar to, but more indistinct than in, *paniquita;* anterior half bisected by a fine longitudinal line, parallel to which on each side is a sharp carinule, the surface broadly and shallowly concave between the lateral carinules; mesonotal laminae well developed and sharply defined mesad by a foveolate impression; axillae large, subovate, dorsal surface weakly concave, lateral edges with an indistinct reflexed margin; suture between mesonotum and scutellum strongly impressed; scutellum flatly tumid, finely and longitudinally striatopunctate, anterior margin subfoveate, posterior margin foveolate; postscutellum simple, finely punctate. Mesopleura subopaque to fulgid; finely punctate, the prepectus and upper portion of pleura traversed by fine, sharp, subhorizontal, parallel carinulae; anteriorly with a sharp epicnemium which is continuous ventrally with the sharp and transversely margined anterior edge of mesosternum; episternauli and sternauli wanting; omauli and the straight oblique episternal suture strongly foveate; hyposternauli present, well developed for their entire length, strongly foveate; mesopleurauli short, strongly foveate; a weak to evanescent carina before middle coxae; hind margin strongly foveolate; metapleura subfulgid, finely puberulent, traversed by parallel, horizontal aciculation, hind margin foveolate. Propodeum opaque; with an inconspicuous vestiture of short, suberect, aeneous to silvery puberulent hair; dorsal face with a large subsemicircular enclosure defined by a series of strong, subcontiguous carinules radiating from the anterior margin; posterior face with a narrow, obcuneate, immargi-

nate discal impression which is opaque and scabrous within, the lateral surfaces traversed above and below by a series of horizontal, parallel carinules, the surface between the carinules closely acupunctate; lateral carinae present for entire length, simple below; lateral faces fulgid, horizontally aciculate.

Legs stout, relatively simple. Tarsi with last segment large, strongly inflated; claws normal; pulvilli large and distinct; fore tarsi not flattened or otherwise modified, without a distinct pecten. Middle tibiae moderately spinose on outer faces, and with a distinct apical calcar. Hind tibiae moderately to strongly spinose on outer faces, the outer posterior face with a rather broad, shallow, concave groove running lengthwise on basal half of tibiae, the inner faces furnished with a thick pile of short, aeneous, velvety pubescence, and apically with two acuminate calcaria, the longer two-thirds the length of hind metatarsi.

Fore wing with marginal cell four times as long as wide, broadly and obliquely truncate at apex; radial vein with first abscissa about one-half (.53) the length of second abscissa; transverse cubital vein straight, oblique, inclivous, one-half the length of second abscissa of cubitus which in turn is about six-tenths the length of first abscissa of cubitus. Hind wing with the anal lobe small, cuneate, distinctly separated off from axillary region, and but one-half length of submedian cell.

Abdomen sessile, subfusiform. Tergites with a thin and inconspicuous vestiture of short, decumbent, light aeneous puberulent hair; first three tergites with a fine but distinct, close puncturation throughout, remaining tergites with inconspicuous and well separated acupunctures; second and third tergites with moderately strong subbasal strangulation; third to fifth tergites inclusive with basal acarid chambers; ultimate tergite with a trigonal pygidial area which is more or less excavate and very strongly narrowed apically. Sternites nitidous and practically glabrous save for a transverse preapical row of erect setulae.

Male.—Unknown.

Only the unique female of this species is known.

Chimila[65] new genus

The short anal lobe of the hind wing, the position of the ocelli, the arcuate subapical emargination of the mandibles and the shape of the female pygidial area, all attest the close relationship of *Chimila* to *Paë*. But the structure of the head and thorax is markedly different in the two entities. In *Chimila*, the clypeus has a simple, flat, subhexagonal median lobe; the mandibles are simple at apex and are furnished with but one dentiform angle immediately basad of the subapical arcuate emargination; the occipital carina merely attains the hind angles of the hypostomal carinule bordering the oral fossa; while on the thorax the pronotum and mesosternum are both rounded and ecarinate anteriorly, and the mesopleura are fulgid, finely and sparsely punctate and devoid

65 After the Chimila Indians of Colombia.

of both hypersternauli and mesopleurauli. Conversely, in *Paë*, the clypeus is armed with a characteristic porrect nasutiform process; the mandibles are bifid at apex and provided with two dentiform angles immediately basad of the arcuate subapical emargination. Furthermore, as in the members of the Foxita complex in the restricted sense, the occipital carina is a complete circle in extent, strongly flanged and foveolate. Finally, both the pronotum and mesosternum of *Paë* are sharply and transversely carinate, while the mesopleura are more or less opaque, horizontally striate to finely costulate, and unique in possessing both hypersternauli and mesopleurauli.

Generic Characters.—Fulgid, finely punctate, medium sized forms. Head subquadrate in anterior aspect, transversely subrectangular in dorsal aspect; temples moderate, normal, not inflated as in *Paë*. Eyes naked, more coarsely facetted anteriorly than posteriorly; inner orbits very strongly convergent toward clypeus and antennal sockets. Malar space wanting. Front with upper portion flat and on same plane as vertex, and not bisected by a carinule, the anterior vertical aspect very narrow and somewhat concave but without a marginate scapal sinus. Vertex without supra-orbital foveae; ocelli rather large, arranged in a low isosceles triangle tending toward a curved line; occipital carina well developed, attaining the hind angles of the hypostomal carinule bordering the oral fossa. Antennae distinctly thirteen-segmented in males and twelve-segmented in females, situated low on face on dorsal margin of clypeus, the sockets contiguous to each other and to nearest lower inner orbit; scapes straight, subcylindrical, elongate, flat anteriorly and longitudinally bicarinate, *i.e.* both inner and outer margin with a sharp longitudinal carinule; pedicel subcylindrical, subequal to slightly longer than first flagellar article; flagellum simple in both sexes, without fringes of hair beneath in males. Clypeus short and transverse laterally, medially with a flat to weakly tectate subhexagonal lobe which is more or less truncate apically. Maxillary palpi with six segments, labial palpi with four segments. Mandibles stoutly subfalcate, the apices simple in both sexes; lower margins entire; inner margins arcuately excised just before apex and thus producing an obtuse preapical dentiform angle, and on basal half with a large acute tooth. Females without a psammophore.

Thorax with pronotum short, transverse, situated on a level with the mesonotum, rounded and ecarinate dorsally and laterally, but hind margin very strongly impressed. Mesonotum simple, more or less striate, transversely so anteriorly and obliquely posteriolaterally; with well developed laminae overlying the bases of the tegulae laterally; axillae large, their lateral margins broadly rounded; scutellum and postscutellum simple. Mesopleura fulgid, finely punctate; anteriorly with a sharply margined epicnemium on prepectus; with a sharp and strong vertical carina before middle coxae; mesopleural pit distinct; episternal suture foveate; episternauli, mesopleurauli, hypersternauli and sternauli all absent. Mesosternum rounded anteriorly. Propodeum finely sculptured; dorsal face with a large semicircular enclosure; posterior face bisected by a vertical impression; lateral carinae present, well developed for entire length and simple below.

Legs simple. Fore tarsi not appreciably flattened in either sex; females

with a weak pecten. Middle tibiae with an apical calcar in both sexes; hind tibiae not sulcate on outer posterior face, furnished with two calcaria. Claws normal; pulvilli large.

Fore wing with marginal cell at least three times as long as wide, and broadly, squarely truncate at apex; radial vein with the first abscissa slightly more than half (.55) the length of second abscissa; transverse cubital vein oblique, slightly sinuate, and about one-half (.55) the length of the second abscissa of cubitus which is three-fifths the length of first abscissa of cubitus. Hind wing with the anal lobe elongate-oval, distinctly separated off, and but one-half the length of submedian cell.

Abdomen sessile, fusiform, impunctate to finely punctate; second to fifth tergites with basal acarid chambers but without traces of strangulation. Females with a pygidial area which is very strongly narrowed apically. Males without a pygidial area on ultimate tergite, the puncturation of which is somewhat more distinct than on preceding tergite; all sternites, as well as inflexed portions of tergites, simple, without processes or tubercles.

GENOTYPE: *Chimila paë* new species.

The genus *Chimila* has been erected primarily for the reception of the following distinctive Neogaeic species, *Chimila paë*. Like *Paë*, the present genus is evidently another of the little known entities inhabiting the tropical forests of South America.

Chimila paë[66] new species

The distinctive conformation of the clypeus and mandibles, and the unusual yellow and pallid livery readily differentiate *Chimila paë* from all other described northern South American Pemphilid wasps.

Type. — ♀; Muzo, Department of Boyaca, Colombia. Elevation, 900 meters. June, 1936. (J. C. Bequaert.) [Museum of Comparative Zoölogy.]

Female.—8 mm. long. Black; the following deep stramineous: mandibles on basal half, clypeus, scapes, pedicel, first flagellar article, pronotum to and including the tubercles, prepectus, axillae, scutellum with a large spot at each anterior lateral angle, postscutellum, fore and middle femora beneath and behind, fore tibiae with a stripe on outer faces, middle tibiae with a similar stripe interrupted medially, hind tibiae with a large ovate preapical spot on outer faces, and abdomen: second, third and fourth tergites with an elongate transverse spot laterally on each side, fifth tergite with the spots larger and united medially, last segment entirely save for apical portion of pygidium. Pallid (lacteous): middle trochanters, hind coxae and trochanters, hind femora entirely save for elongate spots medially on anterior face and distal half of posterior face, first abdominal tergite entirely save for a broad apical border and the caudal half of lateral margins and abdominal venter largely. Dark bruneous: palpi, mandibular apices, apical segments of flagellum, tegu-

66 After the Paë Indians of the central Cordillera of Colombia.

lae and axillary sclerites, all tarsi, legs except for yellow and pallid maculation, and apex of pygidium. Wings clear hyaline, iridescent; veins and stigma brunneous.

Head subfulgid; clypeus, and front along inner orbits and just above apices of scapes, with appressed silvery sericeous pile; upper portion of front and vertex with more inconspicuous, suberect, subaeneous, puberulent pubescence; temples with a vestiture of appressed silvery hair. Front flat to very shallowly concave between inner orbits, discally with an elongate vertical, glabrous and nitidous but immarginate scapal basin which is simple and unarmed medially just above antennal sockets; vertex and upper horizontal portion of front fulgid, with fine, well separated setigerous acupunctures; supra-orbital foveae absent; ocelli situated in a low isosceles triangle (tending toward a curved line), the anterior ocellus less than its own diameter from the hind ocelli, ocellocular and postocellar distances subequal; temples fulgid, with fine setigerous acupuncturation; occipital carina strong, simple, efoveate, attaining the hind angles of the somewhat flanged and foveate hypostomal carinule bordering the subtrapeziform oral fossa. Antenna short, reaching about to occiput, scapes straight, subcylindrical, flat anteriorly and bicarinate, almost three-fifths (.5831) the vertical eye length; pedicel cylindrical; flagellum simple, finely puberulent, first two articles subequal in length, the first seven-eighths the length of pedicel, ultimate article simple, terete, seven-tenths the length of two preceding segments combined. Clypeus flat and arcuately linear laterally, median length one-fourth the vertical eye length, medially with a flat, subhexagonal lobe which is bisected by an almost imperceptible keel, the margin subtruncate, beaded, the lateral margins oblique, beaded, with a double concave margin. Mandibles subfalcate, the apices simple; lower margins entire; inner margins with an arcuate subapical excision forming a preapical dentoid process, the basal half with a large and strong acute tooth. Psammophore absent.

Thorax more or less fulgid; dorsally with a moderate and inconspicuous vestiture of short, erect, light aeneous hairs; pleura and sterna with a sparse clothing of decumbent, longer silvery hair. Pronotum short, transverse, situated on a level with mesonotum, rather strongly inflated dorsally but not carinate anteriorly, the lateral angles rounded, strongly notched medially, pronotal tubercles flat, not attaining the tegulae. Mesonotum lightly arched, finely and transversely striatopunctate anteriorly, obliquely so lateroposteriorly, discoposteriorly with well separated setigerous acupunctures, anterior third with three subparallel, well separated, longitudinal lines medially, laterally with mesonotal laminae overlying the bases of the tegulae; axillae rather large, with lateral margins broadly rounded; suture between mesonotum and scutellum deeply impressed and simple; scutellum flatly tumid; suture between scutellum and postscutellum deeply impressed and indistinctly subconsute; postscutellum simple, finely punctate. Mesopleura perfulgid, with fine, well separated setigerous punctures throughout; anteriorly with a sharply margined epicnemium; episternal suture oblique, straight, and strongly foveate; mesopleural pit distinct; a strong and sharp vertical carina before middle coxae; hind mar-

gin simple, efoveate; metapleura fulgid, finely puberulent, finely horizontally striate, hind margin finely foveolate; mesosternum rounded anteriorly. Propodeum fulgid, dorsal and posterior faces with a very thin and inconspicuous vestiture of short, suberect, light hair; dorsal face with a large, semicircular area poorly delimited by a weakly foveate furrow, anterior margin foveate, disc with fine, well separated, setigerous acupunctures and bisected by a longitudinal carinule; posterior face bisected by a strong vertical furrow laterad of which the surface is subnitidous becoming finely punctate laterally and transversely, horizontally rugulate ventrally; lateral carinae present and more or less distinct for entire length, simple below; lateral faces glabrous and subnitidous.

Legs stout, normal. Middle and hind tibiae moderately spinose on outer faces; middle tibiae with one apical calcar; hind tibiae with two aciculate calcaria, the longer four-sevenths (.572) the length of hind metatarsi; claws normal; pulvilli large; fore tarsi not appreciably flattened or otherwise modified and with a weak pecten.

Fore wings with marginal cell three times as long as wide, broadly and squarely truncate at apex; radial vein with first abscissa five-ninths the length of second abscissa; transverse cubital vein straight, oblique, inclivous, five-ninths the length of second abscissa of cubitus which is three-fourths the length of first abscissa of cubitus. Hind wing with the anal lobe lenticular, distinctly separated from axillary region, and one-half the length of submedian cell.

Abdomen sessile, fusiform, fulgid. Tergites with fine, indistinct, setigerous puncturation, and clothed with a thin vestiture of decumbent, light aeneous hair; second to fifth tergite inclusive with basal acarid chambers; ultimate tergite with a pygidial area which is trigonal basally terminating in an elongate, canaliculate, linguiform process; sternites subglabrous, subnitidous, with a transverse preapical row of erect setulae.

Allotype.—♂; Muzo, Department of Boyaca, Colombia. Elevation, 900 meters. June 20-30, 1936. (J. C. Bequaert.) [Museum of Comparative Zoölogy.]

Male.—6 mm. long. Resembles the female (type) in all essential details of livery and structure excepa as follows:

Livery: Black; the following deep stramineous: scapes anteriorly, pronotum dorsally, pronotal tubercles, prepectus largely, axillae, scutellum anteriorly with two large, almost confluent spots, postscutellum, fore and middle femora posteriorly and at apex, hind femora with a large spot above at apex, fore and middle tibiae with a stripe on outer faces, hind tibiae with a large preapical spot on outer faces. Fuliginous: palpi, flagellum, tegulae and axillary sclerites, femora and tibiae except for yellow markings, and tarsi entirely. Abdomen immaculate black. Wings clear hyaline, iridescent; veins and stigma brunneous.

Head largely as in female, but vertex and front more closely punctate;

ocellocular line about eight-tenths (.81) the postocellar distance. Antennal scapes almost three-fifths (.59) the vertical eye length; flagellum simple, unmodified, finely puberulent, without fringes of hair beneath, first two articles subequal in length, the first five-sixths the length of pedicel, ultimate article simple, terete, five-fourths the length of penult segment. Clypeus of same conformation as that of female, the median length about one-fourth (.235) the vertical eye length. Mandibles as in female.

Thorax in general as in female.

Legs simple, unmodified. Middle tibiae with a distinct apical calcar; hind tibiae with two aciculate calcaria, the longer about five-ninths (.56) the length of hind metatarsi.

Abdomen fulgid, sessile, fusiform. First two tergites with distinct, though fine, puncturation, the remaining tergites with almost imperceptible fine puncturation; first tergite bisected on basal two-thirds by a deep longitudinal furrow; ultimate tergite without a pygidial area, the disc somewhat more distinctly punctate than penult tergite, the lateral margins inflexed but simple and covering the lateral portions of the flat, elongate subrectangular hypopygium which is entire and quadrisetose at apex. Sternites simple, without processes or tubercles, the apical margins entire, more or less truncate.

Specimens examined.—In addition to the typical pair, described above, I have examined two females (paratypes) taken during June, 1936, at Muzo, Colombia. These agree with the type (female) in all essential structural details; the livery of these two specimens is likewise practically the same as that described above for the type.

FOXITA Pate

Foxita Pate, Rev. Entom. (Rio de Janeiro), XIII, p. 368, (1942). [Type: *Foxita atorai* Pate, 1942.]

This interesting genus and its component species have been recently characterized and reviewed elsewhere.[67]

Distribution.—The genus *Foxita* comprehends five species at present. All are confined to the tropical and subtropical areas of the South American continent.

ENOPLOLINDENIUS Rohwer

Enoplolindenius Rohwer, Proc. U. S. Nat. Mus., XL, p. 562, (1911). [Type: *Lindenius (Enoplolindenius) clypeatus* Rohwer, 1911.]

Iskutana Pate, Rev. Entom. (Rio de Janeiro), XIII, p. 390, (1942). [Type: *Enoplolindenius (Iskutana) georgia* Pate, 1942.]

The genus *Enoplolindenius* comprises a dozen species which are referable to two well marked subgenera: *Iskutana* Pate and *Enoplolindenius* in the restricted sense. The genus and its component species have been recently reviewed.[67]

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67 *Cf.* Pate: The New World Genera and Species of the Foxita Complex. Rev. Enttom. (Rio de Janeiro), XIII, pp. 367-421, (1942).

Distribution.—The genus *Enoplolindenius* is confined wholly to the New World. The more generalized species, which are referable to *Iskutana,* are peripheral in distribution (southern and central United States, northern Argentina, southwestern Brazil, etc.), whereas the more specialized forms of the nominate subgenus centre their ranges about the Amazonian basin and southern and central Middle America. This pattern is a striking example of the "age and area" type of distribution.

HINGSTONIOLA Turner & Waterston

Crabro (Hingstoniola) Turner & Waterston, Ann. & Mag. Nat. Hist., (9), XVII, p. 189, (1926). [Type: *Crabro (Hingstoniola) duplicata* Turner & Waterston, 1926.]

Turner and Waterston originally proposed the present entity as a subgenus for the reception of a peculiar new species taken in Sikkim by Major Hingston. Though I know this merely from the figures and description of Turner and Waterston, I believe in the light of evidence now at hand that *Hingstoniola* merits recognition as a discrete genus. Moreover, in all likelihood, it is another representative of the Foxita complex, not too distantly related perhaps to *Vechtia.* From the latter, however, *Hingstoniola* is easily distinguished by the markedly different venation of the fore wing, the structure of the scapal sinus and upper front region, the position of the ocelli, and, in the male sex, by the patellate fore tarsi and the dentate fore femora.

Vechtia[68] new genus

Crabro Bingham, Fauna Brit. India, Hymen., I, p. 321, (1897). [In part.]

The genus *Vechtia* is an Oriental representative of the Foxita complex. The peculiar down-curved laminate production of the dorsal margin of the scapal sinus, the foveolate temporal sulcus, the longitudinally costulate mesonotum, the well developed sternauli, and, in the male sex, the unusually short middle tibiae which are devoid of an apical calcar, all distinguish *Vechtia* from its nearest relative, the Neogaeic entity, *Foxita.*[67]

Generic Characters.—Moderate sized, fulgid, finely punctate forms. Head broadly subrectangular in anterior and dorsal aspects, subquadrate in lateral aspect. Eyes large, naked, more coarsely facetted anteriorly than posteriorly, strongly convergent toward clypeus and antennal sockets. Malar space wanting. Front on anterior vertical aspect between the lower inner orbits with a sharply marginate scapal sinus, the dorsal margin of which is produced into a down-curved laminate plate which overlies the apices of the scapes and bases of flagella when antennae are in repose; upper horizontal portion of front flat, on some plane as vertex, bisected by a longitudinal carinule running forward from median ocellus. Vertex flat; supra-orbital foveae not apparent; ocelli rather large, arranged in a rather low, subequilateral triangle; upper obits margined by a distinct, though narrow, sulcus which is foveolate posteriorly and is thus continued vertically on temples to posterior mandibular condyles;

68 I take great pleasure in dedicating this interesting genus to Dr. J. van der Vecht of the Institut voor Plantenziekten, Buitenzorg, Java, N. E. I.

temples well developed; occipital carina strong and well developed, more or less flanged, foveolate, and a complete circle in extent but separated on mid-ventral line from the well developed and more or less foveolate hypostomal carinule bordering the broad U-shaped oral fossa. Antennae distinctly thirteen-segmented in males and twelve-segmented in females, situated low on face on dorsal margin of clypeus, the sockets contiguous to each other but slightly separated from the nearest lower inner orbit; scape subcylindrical, elongate, outer anterior lateral margin sharply carinate lengthwise, the inner anterior lateral margin longitudinally carinate on basal half; pedicel short, more or less cylindrical; flagellum simple in both sexes, without fringes of hair below in males. Clypeus short, transverse, disc bisected by a strong nitidous keel, and with a short, broad, more or less truncate median lobe. Mandibles stout; apices bifid in males, trifid in females; lower margins entire. Females without a psammophore.

Thorax with pronotum situated on a level with mseonotum and sharply, transversely carinate anteriorly to and including the tubercles. Mesonotum lucid, impunctate but rather strongly longitudinally costulate, anterior half with two widely separated longitudinal keels between which the disc is broadly and shallowly concave; laminae slightly developed at posterior lateral angles; axillary moderate, lateral margins broadly rounded; scutellum longitudinally striate, bisected by a fine longitudinal carinule; postscutellum simple. Mesopleura with fine and separated acupuncturation throughout; prepectus horizontally costulate and anteriorly with a sharply margined epicnemium which is continuous ventrally with the sharp and transversely carinate mesosternum; episternal suture straight, oblique, more or less foveate; mesopleural pit small; before middle coxae with a sharp vertical carina which is continuous ventrally with the well developed sternauli; episternauli, mesopleurauli and hypersternauli all absent. Propodeum short; dorsal face more or less coarsely areolate and separated from posterior face by a transverse carina; posterior face bisected by a longitudinal impression; lateral carinae present, well developed for entire length and bifurcate below.

Legs with all the tarsi simple in both sexes, the metatarsi slender, elongate, subequal in length to or longer than the four distal segments combined; fore metatarsi of females with a very rudimentary pecten of short setulae; claws normal; pulvilli normal. Fore femora and tibiae of both sexes simple, unmodified, edentate. Middle femora and tibiae of females simple, normal, the tibiae subequal in length to femora and with an apical calcar. Males with middle femora somewhat broadened, obliquely flattened below and with a dense brush of hairs there; the middle tibiae short, but one-half the length of femora, and without an apical calcar, but prolonged at apex on inner side into a slender acuminate spinoid process. Hind femora and tibiae simple in both sexes and furnished with two apical calcaria.

Fore wing with marginal cell four times as long as wide and broadly, squarely truncate at apex; radial vein with first abscissa about seven-tenths the length of second abscissa; transverse cubital vein oblique, inclivous, somewhat sinuous, one-half the length of second abscissa of cubitus which in turn is six-

fifths the length of first abscissa. Hind wing with anal lobe large, elongate oval, well separated off, and as long as submedian cell.

Abdomen sessile, broadly subfusiform; finely punctate at most; more or less maculated with yellow. Tergites folded under roundly and imbricate with the strongly convex sternites; second sternite without a small, opaque, finely and closely punctate spot anteriolaterally on each side. Females on last tergite with a distinct pygidial area which is strongly narrowed and excavate apically, the lateral margins glabrous. Males without a pygidial area on ultimate tergite, the puncturation of which is not appreciably more distinct than on penult segment; tergites without inflexed ventral processes; sternites simple, without tubercles or processes; the hypopygium simple, flat, subquadrate or subrectangular, with the apex entire and bisetose.

GENOTYPE: *Crabro spinifrons* Bingham, 1897 [=*Vechtia spinifrons* (Bingham)].

Distribution.—The genus *Vechtia* is an Oriental entity confined largely if not wholly to the Indo-Malayan province. The complex ranges from south-central Siam (Bangkok), through the Malay peninsula (Tenasserim) and Sumatra and well into Java (Buitenzorg and Malang).

DASYPROCTUS Lepeletier & Brullé

Dasyproctus Lepeletier & Brullé, Ann. Soc. Ent. France, III, p. 801, (1835). [Type: *Dasyproctus bipunctatus* Lepeletier & Brullé, 1835.]

Megapodium Dahlbom, Hymen. Europ., I, p. 295, (1844). [Type: *Megapodium Westermanni* Dahlbom, 1844.]

Megalopodium Schulz, Spolia Hymenopterologica, p. 202, (1906). [Emendation for, and isogenotypic with *Megapodium* Dahlbom, 1845.]

The dull opaque habitus, the biepicnemiate mesopleura, and the distinctively shaped petiolate abdomen, stamp *Dasyproctus* as a discrete generic unit. As here understood, *Dasyproctus* agrees in the main with Kohl's characterization in 1915 of the "Attengruppe *Dasyproctus*"[69] and Arnold's definition[70] of the same entity in his monograph of the South African Sphegidae.

In 1915 Kohl, at the suggestion of Brauns, listed *Holcorhopalum* as a synonym of *Dasyproctus*, but although I am not familiar with Cameron's Central American group, I am reasonably certain that *Holcorhopalum* has little if anything in common with *Dasyproctus*.

Distribution.—The genus *Dasyproctus* comprises about fifty species, chiefly Ethiopian and Oriental in distribution, but it is also sparingly represented in the Australian and Eremian faunas. No representatives of it occur in the New World.

Ethology.—The species of *Dasyproctus* nest in the living flower stalks of aloes, lilies, brambles and similar plants, or in the abandoned holes made by wood-boring Bostrichid and Cerambycid beetles in the trunks of trees. The

69 Kohl: Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 328, (1915).
70 Arnold: Ann. Transvaal Mus., XI, p. 357, (1926).

nest is usually in the form of a tunnel, separated into several cells by plugs of triturated pith; each cell is provisioned with a number of Diptera.

Carpenter has recently reported that at Tanga on the East African coast, W. A. Lamborn found *Dasyproctus bipunctatus lichtenburgensis* Arn., nesting in hollow stems during August, 1917.[71] The prey stored consisted chiefly of the Ortalid *Rivellia,* with a few *Aciura tetrachaeta* Bezzi, and also a few unidentified Agromyzids and Dolichopodids. Numerous specimens of a Mutillid wasp, *Promecilla unicingulata* Bischoff, were reared from the nests of this *Dasyproctus.*

NEODASYPROCTUS Arnold

Thyreopus (species-group *Neodasyproctus*) Arnold, Ann. Transvaal Mus., XI, p. 373, (1926). [Type: *T[hyreopus] (Neodasyproctus) Kohli* Brauns (in Arnold, 1926).]

Arnold originally proposed this entity as merely a species group or subgenus, but recently has rejected it along with all the other generic and subgeneric categories of this general complex. Nevertheless, a critical study of the genotypic species, *N. kohli,* indicates *Neodasyproctus* is a valid group worthy of being accorded generic status.

Superficially *Neodasyproctus* resembles *Dasyproctus* but lacks the characteristic opaque dull matt habitus of that genus. Moreover, in the present group the antennal scapes are ecarinate; the scapal basin of the front is immarginate above; the mesopleura, although furnished with a short vertical carina before the middle coxae, lack a sharply margined epicnemium posteriorly for the reception of the middle legs; while the propodeum is coarsely punctate throughout and lacks any trace of a dorsal enclosure or lateral carinae; the mesosternum is rounded and ecarinate anteriorly; the hind wing has the anal lobe distinctly shorter than the submedian cell; and the pygidial area of the female is broad, flat and trigonal. Conversely, in *Dasyproctus,* the antennal scapes are sharply carinate lengthwise; the scapal basin of the front is sharply margined above; the mesopleura are furnished with two sharply margined epicnemia: one anteriorly on the prepectus which is continuous ventrally with the sharply margined mesosternum, and another posteriorly for the reception of the middle legs; while the propodeum as a rule is more or less coarsely areolate or reticulate and provided with distinct and well developed lateral carinae; the anal lobe of the hind wing is usually at least subequal in length to the submedian cell; and the pygidial area of the female is strongly narrowed and excavate apically. Furthermore, in *Dasyproctus* the pronotum is flat above with the anterior and lateral margins sharply and continuously carinate, whereas in *Neodasyproctus* the dorsal surface of the pronotum is both transversely tumid, furrowed and with the anterior but not the lateral margins sharply carinate.

Distribution.—This curious group is known at present only from South Africa.

71 Carpenter: Proc. R. Ent. Soc. London, (A), XVII, p. 48, (1942).

Ethology.—Arnold states that *Neodasyproctus kohli* is rubicolous, nesting in hollow stems.

ECTEMNIUS Dahlbom

Ectemnius Dahlbom, Hymen. Europ., I, p. 389, (1845). [Type: *Crabro guttatus* Van der Linden, 1829.]

Clytochrysus A. Morawitz, Bull. Acad. Sci. St. Petersbourg, VII, p. 454, (1864). [Type: *Crabro comptus* Lepeletier & Brullé, 1835.]

Thyreocerus A. Costa, Ann. Mus. Zool. Napoli, VI, p. 65, (1871). [Type: *Crabro crassicornis* Spinola, 1808.]

Mesocrabro Verhoeff, Ent. Nachr., XVIII, p. 70, (1892). [Type: *Crabro gutatus* Van der Linden, 1829. Isogenotypic with *Ectemnius* Dahlbom, 1845, *q. v.*]

Hypocrabro Ashmead, Canad. Entom., XXXI, p. 168, (1899). [Type: *Crabro decemmaculatus* Say, 1823.]

Pseudocrabro Ashmead, Canad. Entom., XXXI, p. 169, (1899). [Type: *Crabro chrysargyrus* Lepeletier & Brullé, 1835.]

Xestocrabro Ashmead, Canad. Entom., XXXI, p. 169, (1899). [Type: *Crabro sayi* Cockerell, 1910.]

Xylocrabro Ashmead, Canad. Entom., XXXI, p. 169, (1899). [Type: *Crabro stirpicola* Packard, 1866.]

Metacrabro Ashmead, Canad. Entom., XXXI, p. 169, (1899). [Type: *Crabro lituratus* Panzer, 1805.]

Protothyreopus Ashmead, Canad. Entom., XXXI, p. 170, (1899). [Type: *Crabro rufifemur* Packard, 1866.]

Nesocrabro Perkins, Fauna Hawaii, I, pt. 1, p. 25, (1899). [Type: *Crabro rubrocaudatus* Blackburn, 1886.]

Oreocrabro Perkins, Trans. Ent. Soc. London, p. 146, (1902). [Type: *Crabro abnormis* Blackburn, 1886.]

Hylocrabro Perkins, Trans. Ent. Soc. London, p. 147, (1902). [Type: *Crabro (Solenius) tumidoventris* Perkins, 1899.]

Melanocrabro Perkins, Trans. Ent. Soc. London, p. 147, (1902). [Type: *Crabro (Solenius) curtipes* Perkins, 1899.]

Xenocrabro Perkins, Trans. Ent. Soc. London, p. 148, (1899). [Type: *Crabro nesiotes* Pate, 1937.]

Lophocrabro Rohwer, Connecticut St. Geol. & Nat. Hist. Surv., Bull. no. 22, p. 667, (1916). [Type: *Crabro singularis* Smith, 1856.]

Merospis Pate, Entom. News, LII, p. 121, (1941). [Type: *Ectemnius (Merospis) cyanauges* Pate, 1941.]

The genus *Ectemnius*, as understood here, is approximately equivalent to the group which Kohl defined as the "Artengruppe *Crabro*."[72] Many authors have erroneously applied Lepeletier and Brulle's name *Solenius* to it.

The present complex is one of the largest genera of the Pemphilid wasps. About one hundred and fifty species have been described which are referable to it. These species are very diverse in their structural features, and seventeen names have been proposed for various subgeneric entities within the complex. Of these, the following may be recognized as discrete subgenera: *Ectemnius* in the restricted sense, of which *Mesocrabro* Verhoeff is an absolute synonym; *Clytochrysus* Morawitz; *Thyreocerus* Costa; *Hypocrabro* Ashmead, a large assemblage of which Ashmead's groups *Pseudocrabro, Xestocrabro,* and *Xylocrabro* are synonyms; *Metacrabro* Ashmead; *Protothyreopus* Ashmead; *Lophocrabro* Rohwer; and *Merospis* Pate.

72 Kohl: Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 21, (1915).

About twenty endemic Pemphilid wasps have been described from the Hawaiian Islands. For the reception of these peculiar forms, Perkins erected five genera: *Nesocrabro, Oreocrabro, Melanocrabro, Hylocrabro,* and *Xenocrabro.* All of these entities are apparently most closely related to *Ectemnius* in the broad sense, and probably are merely peculiar subgenera of it. Undoubtedly *Nesocrabro* forms a distinct and natural group worthy of subgeneric rank, but the remaining subgenera of Perkins should probably be combined and grouped under the subgeneric name *Oreocrabro,* at least until such time as the Hawaiian Pemphilid fauna may be thoroughly and adequately reviewed.

Distribution.—The genus *Ectemnius* is cosmopolitan with representatives in all the major zoögeographic regions of the world.

Ethology.—The great majority of the species of *Ectemnius* are xyloecetes, nesting in logs, old stumps, dead branches, brambles and canes, or in the abandoned holes of wood-boring beetles. A few construct their burrows in the soil. All provision their nests with a variety of Diptera.

LESTICA Billberg

Lestica Billberg, Enumeratio Insectorum, p. 107, (1820). [Type: *Crabro subterraneus* Fabricius, 1775.]
Solenius Lepeletier & Brullé, Ann. Soc. Ent. France, III, p. 713, (1835). [Type: *Solenius interruptus* Lepeletier & Brullé, 1835.]
Ceratocolus Lepeletier & Brullé, Ann. Soc. Ent. France, III, p. 739, (1835). [Type: *Crabro alatus* Panzer, 1797.]
Thyreus Lepeletier & Brullé, Ann. Soc. Ent. France, III, p. 761, (1835); [*nec* Panzer, 1806]. [Type: *Apis clypeata* Schreber, 1759. Isogenotypic with *Clypeocrabro* Richards, 1935, *q. v.*]
Hypothyreus Ashmead, Canad. Entom., XXXI, p. 171, (1899). [Type: *Crabro subterraneus* Fabricius, 1775. Isogenotypic with *Lestica* Billberg, 1820, *q. v.*]
Clypeocrabro Richards, Trans. R. Ent. Soc. London, LXXXIII, p. 167, (1935). [Type: *Apis clypeata* Schreber, 1759. Proposed as a new name to replace, and isogenotypic with, *Thyreus* Lepeletier & Brullé, 1835, *nec* Panzer, 1806, *nec* Swainson, 1821.]

The genus *Lestica* corresponds to Kohl's 1915 Artengruppe *Ceratocolus.*[73] At least four major subdivisions occur within the genus, and these may be regarded as subgenera as follows: *Lestica* Billberg, in the restricted sense, of which *Hypothyreus* Ashmead is an absolute synonym; *Ceratocolus* Lepeletier & Brullé; *Clypeocrabro* Richards (olim *Thyreus* Lepeletier & Brullé); and *Solenius* Lepeletier & Brullé.[74]

Distribution.—The genus *Lestica* is a moderate sized complex, with representatives in all the major zoögeographic areas with the possible exception of the Australian Region. All the New World forms are referable to the subgenus *Solenius.*

Ethology.—The species of *Lestica* prey primarily upon Muscoidean flies and other Cyclorhaphous Diptera, but there are some records of moths being

73 Kohl: Ann. k. k. Naturhist. Hofmus. Wien, XXIX, p. 107, (1915).
74 Not to be confused with *Solenius* in the sense of Kohl, 1915 and other authors; that group is a subgenus of *Ectemnius* Dahlbom, 1845.

captured and stored in their burrows. The choice of nesting site varies in the different subgenera: the species of *Ceratocolus* and *Lestica* in the restricted sense construct their burrows in sandy soil; those of the subgenus *Solenius* in the stems of pithy plants such as brambles, catalpa and elders, in old rotten wood or logs, or in the abandoned holes of wood-boring beetles. The species of *Clypeocrabro* seem to utilize primarily the abandoned borings of other insects.

GENERA INCERTAE SEDIS

The following entities I know merely from the original descriptions which are usually so incomplete and unsatisfactory that the names cannot be placed with any certitude until the types have been studied carefully. Although treated here for the sake of convenience as genera, they may very possibly be merely subgenera, or, even more likely, synonyms of some one of the preceding groups which are recognized here as valid.

HOLCORHOPALUM Cameron

Holcorhopalum Cameron, Trans. Amer. Ent. Soc., XXX, p. 264, (1904). [Type: *Holcorhopalum foveatum* Cameron, 1904.]

Cameron's description of this Mexican entity is very unsatisfactory. If *Holcorhopalum* is a Pemphilid wasp, it apparently combines certain features of both the *Euplilis* and *Lindenius* groups, and may possibly be related to *Amaripa*. In 1915 Kohl, at Braun's suggestion, placed it as a synonym of the Old World genus *Dasyproctus*, but I consider it very unlikely that *Holcorhopalum* has anything in common with that exclusively Old World complex.

ISCHNOLYNTHUS Holmberg

Ischnolynthus Holmberg, An. Mus. Nac. Buenos Aires, (3), II, p. 472, (1903). [Type: *Ischnolynthus foveolatus* Holmberg, 1903.]

On the authority of Brèthes,[75] I have tentatively referred *Ischnolynthus* to *Crossocerus* (sens. lat.), although I suspect that eventually it will be found to be a member of the *Foxita* rather than the *Crossocerus* complex.

MICROCRABRO Saussure

Crabro (Microcrabro) Saussure [in Grandidier], Hist. Nat. Madagascar, XX, (Hymen.), p. 574, (1892). [Type: *Crabro (Microcrabro) micromegas* Saussure, 1892.]

Saussure established this group as a subgenus for the reception of a peculiar little slender Malagasy species. I know it only from the original description and figures, and from them infer that it may be related to, or perhaps a synonym or subgenus of, the genus *Crossocerus*.

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75 Brèthes: An. Mus. Nac. Buenos Aires, (3), XIII, p. 282, (1911).

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A Revision of the American Spider Parasites of the Genera Ogcodes and Acrocera (Diptera, Acroceridae)[1]

Curtis W. Sabrosky[2]

In attempting to determine specimens of Acroceridae (Cyrtidae) or small-headed flies in connection with a projected List of the Diptera of Michigan, the writer found it practically impossible to name his material satisfactorily with the existing literature. An investigation of the problem revealed a number of interesting points on the classification of these flies, particularly in the genera *Acrocera* and *Ogcodes*. Further study of important materials and types resulted in the conclusions here presented. The paper is based on a total of 157 specimens of *Ogcodes* and 57 of *Acrocera*.

It will be apparent that these conclusions are quite revolutionary in that they are often diametrically opposed to the currently accepted classification, which is based upon the monograph by Cole (1919, Trans. Amer. Ent. Soc., 45:1-79, 15 pls.). If the conclusions prove to be sound, it means that a large proportion of the determined specimens of *Acrocera* and *Ogcodes* now stand in collections under incorrect names, and will have to be reexamined.

Since these conclusions are after all based upon comparatively few specimens (as all work in this rare family is), they should probably be regarded as hypotheses subject to further checking whenever adequate series become available. This is especially true in the genus *Acrocera* where sexual dimorphism is so pronounced and where the proper association of the sexes is therefore difficult at best. My conclusions agree with the facts thus far observed and with the available information on the types. Any material which would aid in settling these problems would be welcomed by the writer.

Frequent reference is made to the excellent plates in Cole's monograph of

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1 Journal Article No. 643 (n.s.) from the Michigan Agricultural Experiment Station.

2 The writer wishes to express his deep obligation to Mr. Nathan Banks of the Museum of Comparative Zoology for his repeated kindnesses in connection with notes on types and checking of the keys. He is further indebted to the following for the loan of important material to extend the scope of the study: Dr. J. C. Bequaert of the Harvard Medical School (who kindly made available the C. W. Johnson collection from the Boston Society of Natural History), Dr. R. H. Beamer of the University of Kansas, Dr. Henry Dietrich of Cornell University, Mr. H. J. Reinhard of Texas A. & M. College, Mr. E. T. Cresson, Jr. of the Academy of Natural Sciences of Philadelphia, Mr. C. S. Brimley of the North Carolina Department of Agriculture, Dr. H. H. Ross of the Illinois Natural History Survey, Mr. F. M. Gaige of the University of Michigan Museum of Zoology, the Director of the Field Museum of Natural History, and Mr. P. W. Fattig of Emory University.

the family in order to avoid repetition of detailed descriptions of wing venation, abdominal pattern, etc.

DIFFICULTIES

Certain difficulties were encountered that were vitally important in the solution of the problems and they may be noted briefly:

1. *Sexual dimorphism* was found to be pronounced in *Acrocera,* so much so that the males and females are often named as distinct species. The dimorphism is not so striking in *Ogcodes,* but seems to be more consistent throughout the genus. It should be mentioned that it is sometimes difficult to tell the sex because of the condition of the abdomen, and one must be careful to avoid mistakes which might influence any conclusions. The abdomen of a male ends bluntly in a fairly large subglobular structure; the female abdomen ends in an elongate tapered ovipositor well illustrated by Fig. 32a of Cole (1919).

2. *Disagreement in the literature.*—The American species have usually been determined by the use of the monograph already referred to (Cole 1919), a paper which contains excellent and very useful illustrations. Because the early descriptions were vague or incomplete in important particulars, Cole was forced to make certain assumptions regarding some of the characteristics of the species in question, notably in *Acrocera,* following the lead of Johnson (1915). A few years later, Brunetti (1926, Ann. Mag. Nat. Hist., series 9, 18:561-606) published notes on the types in the British Museum, and clarified some, though not all, of the points in question. Brunetti's paper has apparently not been used to correct Cole's monograph, or at least no comments have been published on it, perhaps because it appeared in an English journal in a paper dealing almost wholly with tropical and other exotic species. At any rate, Brunetti's descriptions of the types show conclusively that Cole's identifications of several of the species are in error, which upsets the long accepted classification in the family.

3. *Variability of color and pattern.*—Either inherent variation, variation resulting from the degree of maturity of the specimen, or variation induced by environmental influence (e.g. temperature). A series of specimens of *Ogcodes* may show all gradations in the extent or intensity of infuscation on the humeral and postalar calli and scutellum, yet the colors of these areas have frequently been used to separate species. Similarly, in *Acrocera,* one can find several stages in the extent of the spots on the abdomen, and the extremes may appear quite different. It has been especially hard to interpret the color of the legs to determine what pattern is "typical" of a species.

4. *Condition of the specimens.*—In life, the Acrocerids have a globose, apparently inflated abdomen. In pinned specimens, that is all too often collapsed and shrunken, rendering it difficult to interpret the color pattern.

5. *Distribution.*—Since a number of types came from Georgia, some have doubted that the names will apply in the northeastern fauna. Enough material has been seen to show that most if not all of those species are quite widely distributed throughout eastern United States.

OGCODES Latreille

Available keys proved to be particularly unsatisfactory in determining specimens of *Ogcodes*, the common genus of the family, because of the various difficulties listed in the introduction, and especially because the keys are based almost entirely on variable color characteristics. It was not until the writer was fortunate enough to collect in an orchard at Beulah, Michigan, a long series in fine condition (13 males, 25 females, including one pair *in copula*) that he was able to satisfy himself of two important facts which seem to be the keys to the problem of species in this genus. Both of these facts, originally based on the above series, have held true in all other material which has been examined and have therefore been made the basis of the writer's somewhat revolutionary conclusions.

First, males and females differ distinctly in the width of the whitish-yellow fasciae along the hind margins of the abdominal segments, and have been mistaken for separate species. Males have comparatively wide, definite fasciae, those on the fourth and fifth segments usually wider than those on the second and third, the width of a fascia being from one-third or less to as much as two thirds the length of the segment. The fasciae in the females are somewhat indefinite, always narrow to linear or sometimes absent or only faintly indicated, the abdominal dorsum thereby appearing quite dark. The difference is well represented in figures 39 (♀) and 40 (♂) of Cole (1919).

Second, the long series revealed a consistent character in the wing venation which had not previously been emphasized. Vein M_1 (=vein f_1 of Cole's figures) was entirely absent, rarely very faintly indicated near the extreme apex of vein R 4+5 (=vein e of Cole). Other series available for study showed vein M_1 rather completely developed (as in Cole, Fig. 2), usually attached basally to a stub-like portion of the r-m crossvein (=x of Cole) and nearly attaining the margin of the wing. Since aberrations in the wing venation are notoriously common in the Acroceridae, the absence or weak developmen of vein M_1 would have been disregarded had it not been so consistent in the quite obviously homogeneous series of 38 specimens noted above, and so useful when applied to other material.

The importance which I ascribe to this second characteristic merits a word of warning and explanation. The proper distinction between the two types of wing venation (cf. couplet 1 of the key) requires very careful examination of the wing, especially from several angles, in order to eliminate the effect of folding and creasing of the wing membrane. In specimens where M_1 is absent, the wing still tends to fold or wrinkle along the line which the vein would occupy if it were present. If the wing folds at all, the result is often an optical illusion of the presence of a vein in the M_1 position, if one looks at it from most angles. By rotating the specimen, one finally will observe the wing from an angle where one sees only the blank hyaline membrane, perhaps slightly creased along the fold. Sometimes there does appear to be a faint colorless streak along this fold, though never very long, and in such cases it is referred to as "faintly indicated." When the vein is present, however, there is a definite structure present, whatever the angle of view.

The exact interpretation may be easily confused, therefore, by only a quick glance at the wing. The venation, or the absence of veins, seems to show up best when the spotlight shines on a white surface below the wing and the membrane and its veins are seen in silhouette. Specimens with more or less collapsed or wrinkled wings are naturally more difficult to analyze correctly. In good specimens with fully expanded wings, the wing membrane is nearly flat and it is possible to determine readily the presence or absence of vein M_1.

The color pattern on the legs may be characteristic for the species, and has been stated in some cases. However, in general, it varies so greatly with the condition of the specimens that it is hard to interpret even in a long series and is often entirely unusable in connection with a single example.

The same may be said of the use of the color of the humeri, the postalar calli, and the scutellum. While a species may have a usual habitus in regard to the color of these areas, too much emphasis on them in a key (cf. Cole, 1919, p. 61, couplet 5) makes it impossible to place many a specimen. Wherever possible, therefore, the use of these characters has been avoided, or at least they are not the primary choice.

KEY TO THE EASTERN SPECIES OF OGCODES [3]

1. Vein M_1 (= f_1 of Cole 1919) rather completely developed as in Fig. 2 of Cole, usually attached basally to the stub of r-m crossvein (=x of Cole) and extending nearly to the margin of the wing, usually exceeding the apex of vein R_4+5 (= vein e of Cole) 2

Vein M_1 absent, or at most only a short distal portion very faintly and weakly indicated, appearing like a slight crease in the wing 6

2. Thorax chiefly yellow to dark orange, with more or less distinct indications of one or three stripes on the disk of the mesonotum 3

Thorax chiefly black, the disk of the mesonotum entirely so 5

3. Disk of the mesonotum bright orange-yellow to brownish-yellow, sometimes with slight indications of stripes such as a narrow median line, or short narrow vittae dorsal to the postalar calli *(O. dispar)* 4

Disk of the mesonotum dark, orange to brown, with three broad, nearly confluent, black stripes, the median one obsolescent posteriorly and the two lateral stripes abbreviated anteriorly ..... *O. vittatus* Johns

4. Dorsum of the abdomen bright orange yellow, with brownish black spots at the extreme sides about the spiracles (♂) ..... *O. dispar* Macq.

Dorsum of the abdomen chiefly dark brown, the segments with narrow whitish-yellow posterior marginal bands (as in Fig. 39 of Cole) (♀) ..... *O. dispar* Macq.

5. Humeri, postalar calli (= prescutellar callosities of authors), scutellum and entire pleura, black; all femora entirely black (Calif.). ..... *O. melampus* Loew

Some or all of the above areas partly white, yellow or brownish yellow; femora at least partially deep yellow to brown ..... *O. pallidipennis* Loew
(= *O. costatus* Loew)
(= *O. incultus* O. S.?)
(= *O. borealis* Johns.?)

6. Males 7

Females (At present I know for sure only the female of *O. eugonatus*. If it is run through the male side of the key, it will run to *eugonatus* without any trouble.

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3 In both genera, the lack of western material has necessitated emphasis on the eastern species, although the others are included where possible.

having still narrower abdominal bands, and the color pattern of the legs even more distinct than in the males. It is probable, of course, that when the other females are known positively, female *eugonatus* will have to be checked and keyed out more carefully).

7. Abdominal dorsum white, with only remnants of black areas; hair on thorax notably dense and long ..... *O. albiventris* Johns.

Abdominal dorsum chiefly black or dark brown, with regular pale bands along the hind margins of the segments 8

8. Wide whitish-yellow bands on the posterior margins of the abdominal segments, 1/2 - 2/3 the length of a segment (Fig. 42 in Cole); fore and middle femora yellow, browned basally, the hind femora black on their basal two-thirds; vein M_1 appearing faintly indicated distally (Wyo.) ..... *O. albicinctus* Cole (= *O. marginatus* Cole, preoc.)

Abdominal bands narrower, about one-third or less the length of a segment (approximately like Fig. 40 in Cole, as far as abdomen alone is concerned); all femora black or blackish on their basal third to two-thirds, the infuscation least extensive on the fore femora and most extensive on the hind; vein M_1 absent, sometimes the wing slightly folded towards the margin so it appears as if M_1 were faintly indicated (Eastern U. S.) ..... *O. eugonatus* Loew

SPECIES NOT INCLUDED IN THE KEY

1. OGCODES HUMERALIS O. S. (N. Sonora) and O. AEDON Townsend (Lower California).—The wing venation is not stated in the descriptions and neither species can be properly placed in my key. However, they are far out of the normal range of eastern species, besides which most of the latter antedate them. I have seen one female from Orange Grove, San Diego, California, which might possibly be *O. aedon*, and it has the reduced type of venation as in *eugonatus*, but has somewhat broader white abdominal fasciae than usual in females.

2. OGCODES NIGER Cole (Utah, type female).—I hesitate to make a definite statement of the position of this species. Cole in Fig. 41 seems to show a long complete vein M_1 present, though it is only a dotted line and perhaps was only faintly indicated. The stub of r-m crossvein is absent, which is not true in those species in my key which have vein M_1 definitely present. Perhaps we have here a species, or a sex, with an intermediate type of venation.

Certainly the relation of *niger* Cole to *albicinctus* Cole and *rufoabdominalis* Cole should be investigated. Both of the latter were described from male holotypes, the former from Wyoming and the latter from Utah. Since the difference in the width of the abdominal bands is now known to be a sexual, rather than a specific characteristic, it is conceivable that some synonymy may be involved, though not necessarily so.

3. OGCODES RUFOABDOMINALIS Cole (Utah, type male).—Wing venation unknown to me. It should be an easy species to recognize, at least the males, judging from Cole's figure of the abdomen (Fig. 43). If vein M_1 is present, the figure will easily separate males from other species in that group; if vein M_1 is absent, it will come close to *albiventris* Johnson (q.v. for further discussion). Cole's later notes (1923) on a female which he designated as neallotype also do not mention the wing venation.

OGCODES ALBIVENTRIS Johnson

Oncodes albiventris Johnson, 1904, Psyche **11**:18 (Ontario).

Mr. Nathan Banks kindly examined the holotype and reported that it is a male and that it has the reduced type of wing venation, with vein M_1 and the stub of r-m crossvein entirely absent. It can therefore be placed in the key with much more certainty than would otherwise be possible. Mr. Banks also noted that the hair on the thorax is "very dense and plainly longer than in any other males in collection."

Ogcodes rufoabdominalis Cole may come to this place in the key if it is finally found to have reduced wing venation. Both species were described as having the abdomen chiefly whitish-yellow to orange-yellow with only a few strongly delimited black marks. Aside from a few differences in the notes on the abdominal pattern, the following points taken from their descriptions may prove to be useful means of separation:

Basal halves of all femora black; veins light yellow .....*O. albiventris*
Femora brownish-yellow; veins blackish-brown and very distinct.....*O. rufoabdominalis*

OGCODES DISPAR Macq.

Oncodes dispar Macquart, 1855, Dipt. Exot., Suppl., **5**:67 (Maryland).

Females of this species did not seem to be adequately handled in Cole's key, although the male was strikingly distinct and easily recognized. Through the kindness of Mr. Cresson, I was able to check the characters of each sex on the pair taken *in copula* at Swarthmore, Penn. (cited in Cole, 1919, p. 67).

The color pattern of the male will serve to distinguish that sex without trouble (cf. Cole, Fig. 39a). In this and other males which I have seen, the thorax and scutellum are, like the abdomen, bright orange-yellow, in one case with a trace of a narrow dark reddish median stripe on the mesonotum.

In the female noted above, the thorax is rather brownish-yellow, darker posteriorly, and with a faint suggestion of stripes on the mesonotum. However this may be due to the condition of the specimen, for the body wall is transparent, and the appearance is affected by the underlying muscles and fatty tissue. The scutellum is reddish brown on both sexes, the humeri, propleura and postalar calli are conspicuously whitish yellow; the pleura are chiefly yellow but with a white area below the wing base and the lower portion gray to black; metanotum orange, coxae yellow; legs yellow, a little darker in the females than in the males; squamae brownish.

For the relation of *O. dispar* and *O. vittatus*, see the latter name.

New records of *O. dispar*: ILLINOIS: ♂, Du Bois, Aug. 8, 1917 [Ill. Nat. Hist. Survey Colln.]. IOWA: ♂, Cedar Rapids, July 4, 1927 (N. K. Bigelow) [Univ. Mich. Mus. Zool., det. G. Steyskal]. TEXAS: ♂, College Station, March 28, 1932 (H. J. Reinhard) [Tex. A. & M. College Colln.].

Both the Illinois and the Iowa specimens are in excellent condition, very brightly colored, and without stripes on the dorsum of the thorax.

OGCODES VITTATUS Johnson

Ogcodes vittatus Johnson, 1923, Psyche **30**:50-51 (N. J.).

Too few specimens in first-class condition have been examined for me to distinguish adequately between *O. vittatus* and *O. dispar*. For a time it appeared that *O. vittatus* (described from a single female) was the dark or perhaps only the fully matured female of *dispar*. However, one male from Texas was found to have the typical *vittatus* pattern of three broad black stripes on the mesonotum, justifying the separation of *vittatus* and *dispar*. In most respects, such as the color of the pleura, halteres, and metanotum, the two are very similar. Both legs and scutellum varied in color in available specimens of *vittatus*, and I am unable to state the typical condition of those features.

Male *vittatus* has a very dark mesonotum, the stripes broad and nearly confluent, leaving paler areas near the humeri and immediately anterior to the scutellum. The abdomen is dark brown with yellow hind marginal bands, which as usual in the male sex are wider than the corresponding bands in the females. In the male of *vittatus*, however, the bands are roughly equal in breadth on all segments, and occupy only $^1/_4$ - $^1/_5$ the length of a segment.

New records of *O. vittatus:* NORTH CAROLINA: ♀, Raleigh, May 18, 1926 (C. S. Brimley) [N. C. Dept. Agr. Colln.; recorded in "Insects of North Carolina," p. 335, as *O. costatus*]. TEXAS: ♂, ♀, College Station, July 13, 1923 (♂), and May 14, 1928 (H. J. Reinhard) [Texas A. & M. College Colln.]. VIRGINIA: ♀, Great Falls, May 8, 1921 (W. T. M. Forbes) [Cornell Univ. Colln.].

The Virginia specimen is darker than the others, having a pitch black scutellum and entirely dark brown legs, only the knees and extreme narrow apices of the tibiae yellow. It is possible that this will prove to be typical of fully matured specimens, for traces of the color pattern show in the other specimens whose legs are all light yellowish brown without strong contrast.

OGCODES MELAMPUS Loew

Oncodes melampus Loew, 1872, Cent. X, no. 17. (Calif.)

Two California examples before me agree well with the original description and with notes on the type furnished by Mr. Banks. Although not an eastern species, it is included here to make the key complete as far as possible for the species known to me.

It is much darker than any of the other species of *Ogcodes* in my key and will be easily distinguished in that way. The humeri, propleura, postalar calli, scutellum and pleura are entirely black and the halteres are dark grayish-black. The legs are predominantly black or dark brown, the femora entirely black, the tibiae infuscated especially on their dorsal and anterior surfaces. In the wings, the stub of r-m crossvein and vein M_1 are both present, but the latter is not complete and not attached basally to r-m. Since it is distinctly present, however, especially the distal half, it will key out under the first choice without difficulty. The abdomen is like that in Fig. 40 of Cole (1919), the hind mar-

ginal bands perhaps a trifle wider. The pile of the thorax is whitish-yellow, erect, and quite long.

Material examined: *California:* 2♂, Berkeley, Aug. 30, 1919 [Cornell Univ. Colln.].

OGCODES ALBICINCTUS Cole

Ogcodes marginatus Cole, 1919, Trans. Amer. Ent. Soc. **45**:67. (Wyo., Kans.).
O. albicinctus Cole, 1923, Psyche **30**:47 (n.n. = *marginatus* Cole nec Meigen).

The species can be placed in my key with certainty, at least the male sex, because of the loan of the holotype from the Cornell University Collection through the courtesy of Dr. Henry Dietrich.

The wing venation is close to that of *O. eugonatus*, vein M_1 only faintly indicated near the margin of the wing, although the stub of r-m crossvein is distinct. The thorax is dark, with black humeri, propleura, postalar calli, scutellum and pleura. Fig. 42 in Cole is an excellent sketch of the abdomen, showing the unusually broad white fasciae, those of segments 4 and 5 being from ½ to ⅔ the length of the segment. The legs are strongly marked in black and deep yellow, reminiscent of *eugonatus:* the coxae and trochanters are black, the hind femora are black on their basal ⅔, but the fore and mid femora dark brown only on their basal fifth, and the tibiae are chiefly yellow but browned on the upper half. The whitish body pile is long and erect.

Some Texas males identified as *eugonatus* have rather wide bands on the fourth and fifth abdominal segments but none approach the width of that on segment three in *albicinctus*. It is possible, however, that the two may intergrade, at least insofar as the appearance of the abdomen is concerned. The two species are indeed close in general habitus.

OGCODES PALLIDIPENNIS Loew

Oncodes pallidipennis Loew, 1865, Cent. VI, no. 32 (Penn.).
Oncodes costatus Loew, 1869, Cent. IX, no. 67. (Mass.) New synonym.
Oncodes incultus O. S., 1877, *Western Diptera*, p. 279. (N. H.) New synonym (?) or var.
Ogcodes borealis Cole, 1919, Trans. Amer. Ent. Soc. **45**:68. (Quebec). New synonym (?).

Inasmuch as the above names have been recognized by American dipterists for many years, the conclusion that they are synonymous is a radical innovation which requires further explanation.

A detailed analysis was made of a long series of specimens, especially 43 examples from the C. W. Johnson Collections at the Boston Society of Natural History, most or all of which had been reviewed by Cole (1919). This series was distributed about equally among the first three names cited above. At the same time, the writer was fortunate in having for study the fine series of 38 specimens from Michigan referred to in the general discussion under *Ogcodes*.

When both series had been carefully analyzed and segregated, in the light of my observations on sexual dimorphism and types of wing venation (cf.

discussion under *Ogcodes*) and in conjunction with notes from Mr. Banks on the types of all species concerned, the following conclusions were reached:

1. The Michigan specimens, plus five from *pallidipennis* of Johnson, have the reduced type of wing venation (second choice in couplet 1) and are referred to *Ogcodes eugonatus* Loew (q.v.). The other specimens had the more complete type of venation.

2. The Johnson material stood in the collection as follows:

pallidipennis included the smallest specimens (3-5 mm., mostly about 4 mm.), seven males and five females.

costatus included medium-sized individuals with broad white abdominal fasciae, thirteen out of sixteen under the name being males. Cole (1919, p. 64) remarked that he had seen only males in all material of this species, and his illustration (Fig. 40) is that of a male.

incultus included the fifteen largest specimens (5-9 mm.), which in most cases (though *not* in all) had more or less distinctly browned wings, and which were females except in two instances.

The same relation has been found in other collections and appears to represent the prevalent conceptions of those species as evidenced by the determinations of Cole, Johnson and other authors.

3. After segregating *O. eugonatus*, no consistent distinctions could be found for separating the material into three species. One finds that the species have apparently been divided by authors partly on the basis of size (a very unreliable criterion in parasitic flies), partly on the width of the white abdominal fasciae (shown to be a sexual character), and partly on the basis of the brown color of the wing membrane and legs (both variables).

4. I am therefore led to conclude that all three names refer to one and the same species, though the extremely large and heavily browned forms known as *incultus* may possibly merit recognition. While it is true that the extremes look quite different, I find it impossible to draw a line of demarcation at any point among the intermediates.

5. I cannot recognize *O. borealis* Cole from the description or from the notes furnished by Mr. Banks. The type has vein M_1 present and will therefore run under the first choice of the key. The legs, including the tarsi, are wholly pale yellowish. According to Mr. Banks, the holotype (female) is not teneral, and appears to be a good species on the basis of the pale legs. Inasmuch as no material has been seen which could not be related to the range of variation in *pallidipennis*, I am inclined to question the distinctness of *borealis*, although it may yet be found valid.

Material examined and determined as *O. pallidipennis* (*indicates brown-winged specimens of var. *incultus*): ARKANSAS: ♂, Washington Co., Aug. 17, 1942 (coll. at light) [Ill. Nat. Hist. Survey]. CONNECTICUT: ♂, Hamden, June 26, 1928 (B. H. Walden) [Boston Soc. Nat. Hist.]. ILLINOIS: 2♂, 2♀, Edgebrook*, June 25, 1914, July 22, 26, Aug. 7, 1913 (E. Liljeblad) [Field Mus.]; 4♂, 5♀, Odin, May 31, 1910 (♂, "in meadow") and June 2, 1909 ("on dead twigs of elm"); ♀, Urbana,

June 25, 1904 (Hart & Kegley); ♂, Carbondale, May 30, 1904 (Taylor); ♂, Centralia, May 29, 1909 (Girault); ♀, Oak Park*, July 9, 1914; ♂, Springfield, Aug. 24 ("trunk of apple tree"); ♂, Edwardsville, June 4, 1941 (Ross & Mohr) [Ill. Nat. Hist. Survey Colln., the Odin, Urbana and Carbondale specimens det. as *O. costatus* and so published in Malloch, 1915, Bull. Ill. State Lab. Nat. Hist., 11 : 341-2]. MAINE: ♂, E. Eddington, June 25-July 5 (Hough) [Hough Colln., now at Field Mus.]; ♂, Orono, June 28, 1912 (O. A. Johannsen) [Cornell Univ.]. MASSACHUSETTS: ♀, Norwell*, pupa collected July 4, 1937 "in spider web on underside of leaf" (Richard Dow); ♂, 2♀*, Southbridge, June 20, 1919; ♂, Sherborn, July 11, 1926; ♂, Reading, June 25, 1933 (Richard Dow) [All in Boston Soc. Nat. Hist. Colln.]. MICHIGAN: ♂, ♀, Cheboygan Co., June 28 (♂) and 29, 1935 (F. R. Manlove, M. W. Sanderson) [Kans. Univ.]; ♂, Agricultural College, July 13, 1893 [Mich. State College Colln.]; Walnut Lake, July 12, 1906 (J. G. Needham) [Cornell Univ.]. NEW YORK: ♀, Potsdam* (C. O. Houghton), det. Cole as *O. incultus;* ♀, Enfield*, Aug. 4, 1923; ♀, Grass Bog, McLean Res., Sept. 17, 1924 [all, Cornell Univ. Colln.].

In addition to the above, the following specimens from the Boston Society of Natural History, upon which were based the records in Johnson's "Diptera of New England" (1925), have been determined as *pallidipennis:* 3♂, 1♀, determined in collection as *pallidipennis*, from Belfast, Wales and Monmouth, Maine, and Hampton, N. H.; 13♂, 3♀, determined in collection as *costatus*, from Princeton, Monmouth, Wales, S. W. Harbor, Orono, and Waterville, Maine, Shirley Hill, Hampton, and Glen House, N. H., North Saugus, Lexington, Framingham, Swansea, and Fall River, Mass., Apponaug, R. I., and Lyme, Conn.; 2♂, 13♀*, determined in collection as *incultus*, from Wales, Paris, Foxcroft, and Monmouth, Maine, Hampton and Rumney, N. H. (The latter specimen collected July 1, 1926, by P. J. Darlington, "on dead twigs of *Alnus*"), Holden, Natick, Fall River, Cohasset, Sherborn ("on chestnut stump in woods"), Arlington, and Auburndale, Mass., and Cornwall, Conn.; 4♀, determined as *incultus* var., from Waterville, Maine, Hampton, N. H., and Fall River, Mass.

Three specimens (♂, Chester, Mass., Aug. 9, 1912, C. W. Johnson; ♂, Framingham, Mass., July 5, 1908, C. A. Frost; and ♀, Wales, Maine, July 11, 1904, C. A. Frost) are somewhat intermediate between *pallidipennis* and *eugonatus* in wing venation. They were determined in the collection as *pallidipennis*, and have now been labeled as intermediates, but it may be that they are actually specimens of *eugonatus* in which vein M_1 is partially developed. They resemble the latter species in appearance because of their small size (2.5-3 mm.) and black femora.

OGCODES EUGONATUS Loew

Oncodes eugonatus Loew, 1872, Cent. X, no. 18. (Texas).
Equals *O. pallidipennis* of authors, in part.

The discovery of the importance of the reduced type of wing venation has already been discussed elsewhere. The common eastern species having this type of venation is found to be *O. eugonatus* Loew, as confirmed from the type.

The writer was fortunate enough to collect a good series of 38 specimens (13 ♂, 25 ♀), including one pair *in copula*, in about an hour in a neglected orchard on the north shore of Crystal Lake, near Beulah, Michigan. In most cases they were found clinging to the under side of dead twigs on dead or dying young cherry trees, rarely on dead spurs on apple trees. In no case were they taken on twigs bearing leaves. They were easily captured by placing a small bottle over them, and only occasionally did one escape with a quick buzzing flight reminiscent of small Tachinidae. None could be found on the trunk or large limbs, but only on twigs about the diameter of their own bodies, in the open and sunny tops of young trees. Fourteen specimens were collected in less than a quarter hour on a small cherry tree only five feet in height.

A number of other collecting records, in this genus particularly, have referred to dead twigs, rolled apple leaves, trunks or branches of apple trees, etc. Careful attention by collectors to dead twigs, especially in abandoned orchards, may result in more material than one usually finds in this comparatively uncommon family. Needless to say, the small black *Ogcodes* are well protected from casual glances by their color and by their habit of clinging closely to their perch.

The size of the males ranged from 3.5-4.5 (aver., 3.94 mm.), and that of the females from 3-6 mm. (aver., 4.14 mm). Of the pair taken *in copula*, the male is 3.5 and the female 6 mm. in length. The wing venation is very consistent. The species is dark, the thorax and scutellum entirely black (occasionally the postalar calli narrowly margined with white), the pleura black with no pale area beneath the wing as in *pallidipennis*. The legs have a distinct and rather sharply demarcated color pattern, which, however, is easily obscured if a specimen is teneral, greasy, or spoiled by the mounting medium. All coxae and trochanters are black and all femora black proximad, and bright, deep yellow on the distal fourth to third, the black color most extensive on the hind femora. Males commonly have paler legs than the females, with all tibiae yellow, or all but the hind tibiae, whereas the females usually have more extensively infuscated tibiae. The tarsi are entirely brownish black to black.

An unusually long series (39 ♂, 49 ♀) was collected in 1943 in the same orchard near Beulah, Michigan, where a good series was collected in 1942, and under the same conditions, resting on dead cherry twigs and very few on dead apple spurs. The experience showed that although the family is regarded as being quite rare, with few examples in most collections, it may be abundant locally though perhaps only in restricted sites. In this instance, for example, a number of trees in the orchard were examined, but only an occasional specimen was found until I came to the same small, five foot, dead cherry tree mentioned for the previous year. It was at once noted that the Acrocerids were especially abundant, not only resting near the tips of the smaller twigs but flitting about among the inner branches as if pursuing each other. No net was used, and all specimens were picked up in my fingers by careful movements. At the end of ten minutes, 28 had been taken, and 50 at the end of twenty minutes, with a final total of about 70 individuals from that one small tree!

One was found dead in a spider web, and one was being carried as its prey by the predaceous bug, *Nabis subcoleoptratus* Kirby, which was common in the deep grass about the base of the small cherry tree.

No evidence could be found of the source of the Acrocerids. At the time there were numbers of tiny spiders, much smaller than the flies, resting at the bases of the dead spurs. It is possible that they were young spiders and the flies had gathered there for oviposition.

A lone specimen of *Acrocera* was collected at the same locality, as two or three had been taken the previous year. It appears that *Acrocera* species are

much less common than *Ogcodes*, but perhaps the situation was more favorable for the latter in some way not yet understood.

The range of size agreed with the stated limits, except that one female (Kewadin) measured only 2.5 mm., the smallest yet recorded.

Material examined: CANADA: ♂, Toronto, Ontario, 1896 (Hough Colln., now in care of Field Museum.) ILLINOIS: 2♀, Odin, Aug. 7, 1894 (Johnson, "in rolled apple leaf") and June 23, 1909 (latter standing in colln. as *O. costatus*); ♀, Zion, July 25, 1934 (Frison & De Long) (Ill. Nat. Hist. Survey Colln.). INDIANA: ♂, White River, Petersburg, June 3, 1936 (Mohr & Burks) (Ill. Nat. Hist. Survey). MAINE: ♂, Great Pond, Mt. Desert, July 16, 1918 (C. W. Johnson); ♀, Monmouth, July 17, 1904 (C. A. Frost); ♀, Wales, July 11, 1904 (C. A. Frost) (Boston Soc. Nat. Hist. Colln., det. as *O. pallidipennis*). MASSACHUSETTS: ♂, Woburn, July 11, 1907; ♀, Springfield (Anna Dimmock) (Boston Soc. Nat. Hist. Colln., det. as *O. pallidipennis*). MICHIGAN: 38 (13♂, 25♀), Beulah, July 15, 1942 (C. W. Sabrosky, coll. on dead twigs of cherry and apple), also one of same date, partly destroyed, entangled in a spider web (Sabrosky Colln., Mich. State College); 2♂, Cheboygan Co., July 12, 1935 (Martha F. Miles) (Kans. Univ.). MICHIGAN: 88 (39♂, 49♀), Beulah, July 16, 1943 (chiefly on dead twigs of cherry); 2♀, Hart, July 15, 1943 (on dead apple spurs); 3♀, eight miles S. of Cheboygan, July 19, 1943 (on dead apple spurs); 1♂, 7♀, Kewadin, July 17, 1943 (on dead apple spurs) (all coll. C. W. Sabrosky) (Sabrosky Colln., Mich. State College); 1♀, N. shore of Burt Lake, Cheboygan Co., July 18, 1943 (Bruce Somerville; on dead branch, eight feet from ground, fairly heavy shade in beech-maple forest) (Somerville Colln.). NEW JERSEY: 3♂, 1♀, Glassboro, Aug. 17, 22, 29, 1940 (beneath codling moth bands) (Rutgers Univ. Colln., Sabrosky Colln.). NEW YORK: ♀, Childwold, July 16, 1933 (H. Dietrich) (Cornell Univ.). TEXAS: ♂, Dickinson, Oct. 2, 1934; ♀, ibid., May 10, 1935, ♀, Mexia, July 14, 1937; 4♂, 4♀, College Station, various dates, May 9, 17, 20, 21, 28, June 1 and 25, 1928-1942 (H. J. Reinhard) [Texas A. & M. College Colln.].

ACROCERA Meigen

It has been found to be impossible to identify most specimens of the genus *Acorema* for various reasons, which were discussed briefly in the introductory remarks. The study of the difficulties involved several different procedures.

1. *Sexual dimorphism.*—In the first place, the writer has found that the males and females are distinctly different in appearance, the males being somewhat smaller and having a great deal more yellow to orange color on the dorsum of the abdomen. The result is a different color pattern and a habitus quite unlike that of the females. When over fifty available specimens of *Acrocera* were sorted by sex, there was evident a strong likelihood that males and females had been considered two different species. This was demonstrated in keys when one came to couplets which separated species on the basis of the predominance of black or of yellow on the abdomen.

2. *Identity of types.*—Secondly, Brunetti's notes on Westwood's types in the British Museum (cf. difficulty no. 2), including five of the oldest available names for North American *Acrocera*, were in several cases the direct opposite of the interpretation of authors (Cole, Johnson, et al.). This obviously necessitated a double correction in each case — establishing the proper application of the older name, and reestablishing the true identity of the species long misdetermined under that name. It is indeed unfortunate that these changes which seem absolutely unavoidable from the evidence, will

necessitate a radical revision of the species as listed and so admirably figured by Cole (1919).

The following list will illustrate the situation resulting from the correlation of Cole's monographs and Brunetti's notes:

Cole (1919) and authors		Revised status
A. fasciata Wied. ♂	=	*A. fasciata* ♂
A. fasciata Wied. ♀	=	*A. unguiculata* Westw. ♀
A. unguiculata Westw.	=	*?A. bulla* Westw. ♀
A. bulla Westw.	=	*A. steyskali* n. sp.
A. nigrina Westw.	=	*A. fasciata* Wied. ♀
A. subfasciata Westw.	=	*A. subfasciata*

The names *nigrina* and *fumipennis*, in the original sense of Westwood, can not be associated with any material which I have seen, as far as Brunneti's notes are concerned.

3. *Published evidence on distribution and sex.*—As a third step in the investigation of the situation, following the analysis of sexual dimorphism, and the testing of prevailing concepts in the light of published notes on types, all available names in the genus were listed with the type locality and sex of each, if the latter were stated or if it could be determined. These are listed herewith, as a check list for ready reference.

THE PUBLISHED NORTH AMERICAN SPECIES OF ACROCERA

Species-author-date of publication	Type locality (state)	Sex of type
A. bakeri Coquillett, 1904	Nev.	Female
A. bakeri var. *arizonensis* Cole, 1919	Ariz.	Female (cf. Cole, fig. 28)
A. bulla Westwood, 1848	N. Y.	Female (*fide* Brunetti)
A. bulla var. *melanderi* Cole, 1919	Mont.	Female
A. bimaculata Loew, 1865	D. C.	Female (males also?—cf. notes)
A. convexa Cole, 1919	Calif.	Male (Allotype, Wash., probably another species)
A. fasciata Wiedemann, 1830	Ga.	Unknown; description suggests male.
A. fumipennis Westwood, 1848	Ga.	Unknown; description suggests female.
A. hubbardi Cole, 1919	Ariz.	Female
A. liturata Williston, 1886	Wash.	Male
A. nigrina Westwood, 1848	Ga.	Female (*fide* Brunetti)
A. obsoleta Van der Wulp, 1867	Wis.	Unknown; description suggests male.
A. stansburyi Johnson, 1923	Utah	Both sexes, type series of eight spms.
A. subfasciata Westwood, 1848	N. Y.	Unknown; description might apply to either sex.
A. unguiculata Westwood, 1848	Ga.	Male, apparently (*fide* Brunetti).

Of the fifteen available names, seven were based on material from the western states, and eight on eastern examples. It is possible, of course, that a Canadian zone species, for example, might range across the country and be found in both areas. Nevertheless, the use of a rough division of the sort often aids in locating a species more quickly.

As for the sex of the types, or type series, the summary shows the following: 3 species described from male sex alone (unknown for *A. obsoleta*, but

the description is certainly that of a male; in the case of *A. unguiculata*, Brunetti reported that the genitalia of the type were too concealed to be sure, but appeared to be those of a male, as would be inferred from the description of the color pattern).

6 species described from the female sex alone.

3 species described from both sexes (possible doubt, however, in cases of *A. bimaculata* and *A. convexa;* cf. discussion under those species).

3 species unknown (Of these, from the descriptions, *A. fasciata* is probably the male, and *A. fumipennis* the female; in *A. subfasciata,* the description might apply to either sex, though female is more likely).

4. *Correlation of evidence.*—The information thus far outlined was then organized into convenient form as a basis for the analysis of the available material. Wing venation appeared to offer the best means of dividing the species into major groups, and it has proved to be a very good character, subject of course to the aberrations occasionally found in flies of this family. The following outline embodies the information from the several lines of evidence, with the position of Westwood's species corrected to agree with Brunetti's notes.

ANALYSIS OF THE DESCRIBED NORTH AMERICAN SPECIES OF ACROCERA

Group I—Vein R_{2+3} present, complete		Group II—Vein R_{2+3} represented only by apical spur	
Males	Females	Males	Females
	(western)		(western)
liturata—Wash.	*bakeri*—Nev. *bakeri* var. *arizonensis*—Ariz. *bulla* var. *melanderi*—Mont.		
stansburyi—Utah	*stansburyi*—Utah		
	(eastern)		(eastern)
subfasciata—N. Y.	*subfasciata*—N. Y.	(?)*bimaculata*—D. C.	*bimaculata*—D. C.
Group III—Vein R_{2+3} absent, both branches of R_{4+5} present.		Group IV—Vein R_{2+3} absent, Vein R_4 (anterior fork of third vein) also absent.	
Males	Females	Males	Females
	(western)		(western)
convexa—Calif.	*hubbardi*—Ariz.		
	(eastern)		(eastern)
unguiculata—Ga. *obsoleta*—Wis. *fasciata*—Ga.	*nigrina*—Ga.		*bulla*—N. Y. *fumipennis*—Ga.

By using this chart, it was possible to reduce the number of eligible names to be considered in any given instance, when trying to solve some of the difficult problems of identification in the genus *Acrocera*. In some cases the

problems remain unsolved. In the case of the western species, I have not had sufficient material to enable me to do more than indicate their position in a very general way, usually based on the description alone.

KEY TO THE NORTH AMERICAN SPECIES OF ACROCERA

1. Second longitudinal vein (=R_{2+3}) present and complete 2
   R_{2+3} absent, or represented only by a short apical rudiment 4

(Group I—Venation complete, R_{2+3} present)

2. Western species, not included in key (see notes)
   Eastern species 3
3. Mesonotum not entirely black, the anterior corners with large cuneiform orange-yellow spots (Fig. 8), which are sometimes more extensive and divide the dorsum into three separate black stripes (Cole, figs. 38, 38a).....*A. subfasciata* Westw.
   Mesonotum entirely black except for the humeri and postalar calli .....
   .....*A. steyskali* Sabrosky

(Group II—Apical spur of R_{2+3})

4. Vein R_{2+3} represented by a short but distinct apical rudiment (Cole, 1919, fig. 32) .....*A. bimaculata* Loew
   Vein R_{2+3} entirely absent 5
5. Third longitudinal vein (=R_{4+5}) forked, both branches present and distinct (Group III) 6
   Vein R_{4+5} with the anterior branch absent, except perhaps for a short basal stub; veins generally pale and weak (Group IV) 15

(Group III—Both branches of vein R_{4+5} present)

6. Sternites of abdominal segments 2-5 broadly black, with much narrower yellow fasciae along the posterior margins, the black area equally broad both mesally and laterally (Fig. 2a) 7
   Sternites of abdominal segments 2-5 chiefly whitish yellow, the basal black fasciae quite narrow mesad but almost as broad as the segment laterad, thus giving the yellow area on each sternum an anteriorly convex margin (Fig. 4a).... 9
7. Females 8
   Males (the male of *A. hubbardi* is unknown to me. The male of *A. fasciata* has a distinct abdominal color pattern, as shown in my fig. 2)
8. Dorsal abdominal pattern as in Cole, fig. 35a, the fourth segment predominantly yellow, with only the basal angles narrowly and a large median triangle black (eastern) .....*A. fasciata* Wied. ♀
   Fourth segment with a broad black fascia occupying the anterior half (Cole, 1919, fig. 31) (Ariz., possibly northward) .....*A. hubbardi* Cole ♀
9. Males 10
   Females 13
10. Second abdominal segment with a black median dorsal triangle separated from the black areas at the lateral angles (Cole, 1919, figs. 29 and 29a) (Calif.)....
    .....*A. convexa* Cole ♂
    Second abdominal segment with a broad black fascia along the entire anterior third of the dorsum, though with a triangular prolongation on the midline (Cole, 1919, fig. 36) 11
11. Both second and third abdominal segments dorsally with complete basal black bands, and a nearly complete band on the fourth (Fig. 3a) .....
    .....*A. hungerfordi* Sabrosky ♂

Only the second segment dorsally with a complete black fascia, the third and occasionally the fourth with only small median black triangles 12

12. Third and fourth abdominal tergites with a considerable extent of black in their anterior lateral corners, in profile the black extending dorsad along the anterior margin from one-third to one-half the height of the tergite (as in Cole, 1919, fig. 36a); propleura partially yellow, along their dorsal margins; fifth abdominal segment as usual, telescoped beneath and partly hidden by the fourth segment ..... *A. unguiculata* Westw. ♂

Third and fourth tergites with only a small amount of black in each anterior lateral angle (as in Cole, 1919, fig. 36b); propleura black; fifth abdominal segment not telescoped but indented, its entire dorsum visible in caudal aspect (Cole, fig. 36b, appearance in profile) ..... *A. sp.* (*obsoleta* V. d. W. ?) ♂

13. Second abdominal tergite with only obscure, irregular traces of yellow spots, or entirely black, sometimes the spots connected to form a continuous band; propleura entirely or chiefly black (Fig. 3) ..... *A. hungerfordi* Sabrosky ♀

Second tergite with a broad distinct yellow fascia along the posterior margin, nearly or quite as broad as the fasciae on the following segments 14

14. Propleura whitish-yellow; second, third and fourth abdominal tergites with regular, parallel-sided orange fasciae along their posterior margins, the second narrow, 1/4 to 1/5 the length of the segment, and the width of the third less than half as long as the segment (fig. 4) ..... *A. unguiculata* West. ♀

Propleura black; the three orange fasciae are broader, the width of the second band over one-third and that of the third band about one-half the length of their respective segments (Fig. 5) ..... *A. sp.* (*obsoleta* V. d. W.?) ♀

(Group IV—R_4 absent)

15. Males 16

Females (not keyed out here; I have three apparently different females before me, but with no idea of how to associate them with the available males).

16. Thorax predominantly yellow, with a broad, posteriorly abbreviated median black stripe and a large round black spot on either side (Fig. 6); antennae whitish yellow; propleura yellow ..... *A. flaveola* Sabrosky ♂

Thorax predominantly black, with some yellow areas just anterior to the scutellum and sometimes behind the humeri (Fig. 7); antennae dark yellow to brown; propleura black ..... *A. bulla* Westw. (?) ♂

GROUP I

WESTERN SPECIES OF ACROCERA

The several western species of Group I have been omitted for lack of material. I suspect that considerable series may be necessary for an adequate understanding of the relation of the sexes and the status of the several species. As far as the descriptions are concerned, *liturata* and *stansburyi* are like *subfasciata* in having the thorax partially yellow and either striped or with the appearance of fused stripes, while the other species (*bakeri*, *bakeri* var. *arizonensis*, and *bulla* var. *melanderi*) have an entirely black mesonotum. I have before me a lone female specimen from Giant Forest, Calif., Aug. 9-13, 1927 (J. C. Bradley) [Cornell Univ. Colln.] which does not agree with any of the above described species and may represent still another form.

ACROCERA SUBFASCIATA Westw.

Acrocera subfasciata Westwood, 1848, Trans. Ent. Soc. London **5**:98 (N. Y.).
A. subfasciata; Johnson, 1915, Psyche **22**:199, fig. 1.

A. subfasciata; Cole, 1919, Trans. Amer. Ent. Soc. **45**:58, figs. 38, 38a.
A. subfasciata; Brunetti, 1926, Ann. Mag. Nat. Hist. (ser. 9) **18**:589.

Johnson, followed by Cole, assumed that *subfasciata* Westwood had complete venation, and fortunately that was correct according to Brunetti's notes on the type.

In three of the specimens recorded below, the orange areas on the thorax are quite extensive, dividing the dorsum into three broad stripes. Even these vary in the relative extent of the stripes, however. In the Willow Springs female, the lateral stripes are comparatively narrow, widely separated from the median stripe and not at all connected with the black pleura, the resulting pattern being like that of *A. liturata* as figured by Cole (Fig. 30). In the Edgebrook and Pelham examples, the stripes are only narrowly separated, and the lateral stripes are continuous with the black pleura (Cole, Figs. 38 and 38a). In all three, the abdomen shows the distinct pattern of a median row of three large black triangles (on segments 2-4) not connected with the lateral black areas as they are in the following specimen (Fig. 8).

The fourth specimen, from Raleigh, N. C., is the only one which agrees in all particulars with the information given by Westwood and Brunetti. The stripes are confluent on the posterior half of the thorax, leaving a large orange spot in each anterior corner of the dorsum, as illustrated in my figure 8 (Westwood: "thorace utrinque maculis duabus cuneiformibus fulvis"). The abdomen is also darker than the preceding, for on segments two and three, the median black triangles are connected basally with the lateral triangles. This pattern also agrees a little better with Brunetti's notes, though the latter are not too definite with respect to the exact appearance of each segment. Brunetti also said that the abdominal venter of the type was "pale yellowish," and this may be an important distinction from *A. steyskali* and perhaps others. The specimens before me are somewhat discolored and I cannot be certain of the pattern on the ventral side.

All four specimens are so similar that they suggest the interpretation of a single species, variable in the extent of black areas on the thorax and abdomen, so that the separate stripes and triangles are sometimes fused into a continuous pattern.

Only females have been seen, although with so few specimens one cannot be sure whether this is a significant point. Length, 3.5-4 mm.

Specimens examined: ILLINOIS: 2♀, Willow Springs, Aug. 22, 1909 (W. J. Gerhard), and Edgebrook, Aug. 17, 1913 (W. J. Gerhard) [Field Mus. Nat. Hist.]. NEW HAMPSHIRE: ♀, Pelham, Sept. 6, 1905 (J. C. Bridwell) [Boston Soc. Nat. Hist., cited by Johnson, 1915, and Cole, 1919]. NORTH CAROLINA: ♀, Raleigh, Oct. 11, 1915 (R. W. Leiby) [N. C. Dept. Agr., recorded as *subfasciata* in "Insects of North Carolina"].

Acrocera steyskali, new species

=*Acrocera bulla* of authors, not Westwood.
Acrocera bulla; Johnson, 1915, Psyche **22**:199.
A. bulla; Cole, 1919, Trans. Amer. Ent. Soc. **45**:54, fig. 27, a, b.

Male: Entirely black, with the following yellow to whitish-yellow marks:

humeri, postalar calli (usually more or less black centrally, and white on the posterior portion and along the upper margin), halteres, legs (except for the black claws and the extreme apex of each distal tarsal segment), a narrow posterior marginal fascia on each abdominal sternite, and a pattern on the dorsum of the abdomen as shown in my figure 1, with the spots as usual varying in extent, those on the second segment in particular being quite small in some specimens. The body is covered with short, appressed, golden-yellow hair. Squamae white with pale margins. Genitalia deep yellow. General appearance and wing venation as figured by Cole (1919, Fig. 27). Length of type, 3.5 mm.; paratypes, 3.5-5 mm.

Female: Darker than the males, the humeri and postalar calli dark, the legs slightly infuscated, the dorsum of the abdomen predominantly black, the squamae dark and with brown margins, and the veins of the wing black. The pattern of the abdominal dorsum of the allotype as in my figure 1a, but in the other specimen the second segment is entirely black, and the spots on the third and fourth segments are much reduced in size and are separated from each other by a median black area wider than either spot. Length of allotype, 5.5 mm.; length of parallotype, 5 mm.

Holotype, ♂, Cheboygan Co., Mich., Aug. 4, 1936 (James L. Bussard). Allotype, Southbridge, Mass., Aug. 19, 1921. Paratypes: ♂, Cheboygan Co., Mich., Aug. 4, 1939 (Eugene Kenaga); ♂, Bailey's Island, Maine, Aug. 20, 1915 (G. M. Allen); ♂, W. Kennebunk, Maine, Aug. 19, 1919 (A. B. Fuller); ♀, Douglas Lake, Cheboygan Co., Mich., July 21, 1926. The three Michigan specimens are from the Snow Collection, University of Kansas, the others from the collection of the Boston Society of Natural History. The two specimens from Maine were recorded by Cole (1919) and Johnson (1925) as *A. bulla*.

The species is named in honor of my friend and ardent fellow Dipterist, Mr. George C. Steyskal, with whom I have been associated for a number of years in a project on the Diptera of Michigan.

Besides the type series, I have before me two small females which probably belong here, but which are so atypical in abdominal pattern that I hesitate to include them. In one from East Jordan, Mich., July 3, 1939 (A. H. Beyer) [Sabrosky Colln.], the abdomen is like that of *A. hungerfordi* (♀); in the other, Sleeping Beauty, Mt. Washington Co., N. Y., July 28, 1920 (S. C. Bishop) [Cornell Univ. Colln.], the spots are reduced in size and irregular in outline. A female in the University of Michigan Museum of Zoology, from Cheboygan Co., Mich., July 6, 1929, also probably belongs here, though the orange areas on the third and fourth segments are reduced to very small insignificant spots.

With reference to the common use of the name *bulla*, Johnson (1915), followed in turn by Cole, stated that "I have taken it for granted that Westwood's species has typical venation," meaning that R_{2+3} (second longitudinal vein) was present. Unfortunately, Brunetti found that the type of *bulla* actually had the extremely reduced type of venation in which not only the second

vein but even the upper branch of the third vein was lacking. There being no available name to replace *A. bulla* of authors, I propose to call the species *Acrocera steyskali.*

GROUP II

ACROCERA BIMACULATA Loew

Acrocera bimaculata Loew, 1865, Centuria VI, no. 33. (D. C.)
A. bimaculata Loew; Johnson, 1915, Psyche **22**:200, fig. 2 (wing).
A. bimaculata Loew; Cole, 1919, Trans. Amer. Ent. Soc. **45**:50, fig. 32.
?=*A. nigrina* Westwood, 1848 (cf. discussion under *nigrina* in Group III).

This is the most readily recognized species of *Acrocera* because of the distinct apical rudiment of vein R_{2+3}, well illustrated by Cole. Strangely enough, this spur-like rudiment appears to be a constant feature in the wing of the species, although there is some variation in its length. In the most extreme example, from Willow Springs, Ill. (Gerhard), in the right wing the apical spur is nearly equal to half the length of a normal vein R_{2+3}, and there is a short but distinct stub at the point where the vein would normally have originated.

No males of *bimaculata* have been seen thus far by the writer, leading one to question whether the male sex may have a different type of wing venation. The "small male" from Southbridge, Mass., mentioned by both Johnson (1915) and Cole (1919), has been examined and is really an undersized female. However, Loew said that he was describing the species from both sexes, and it is possible that males do exist with the same peculiar venation.

There is some variation in the amount of yellow on the predominantly dark abdomen. In some the second segment is entirely black, and the yellow on the third and fourth segment is reduced to two small spots on each segment. In others there are two small spots on the posterior margin of the second segment, and finally the spots are sometimes connected and appear as a narrow fascia along the margin of the segment. In the latter specimens, the yellow areas on the other segments are correspondingly more extensive, though never very conspicuous.

Specimens examined: *Illinois:* 2 ♀, Willow Springs, June 19, 1907 (E. B. Chope) and Aug. 22, 1909 (W. J. Gerhard) [Field Mus. Nat. Hist.]. MASSACHUSETTS: ♀, Southbridge, June 26, 1915 (S. W. Bromley) [Boston Soc. Nat. Hist.]. MICHIGAN: ♀, Cheboygan Co., July 18, 1940 (H. B. Hungerford) [Snow Colln., Kans. Univ.]. NEW YORK: ♀, New Russia, Essex Co., Aug. 18, 1912 (J. C. Bradley); ♀, Fall Creek, Ithaca, June 28, 1926; 2 ♀, McLean Res., Aug. 4 and 24, 1924 [Cornell Univ. Colln.]. NORTH CAROLINA: ♀, Blowing Rock, Sept. 4, 1915 (R. W. Leiby) [N. C. Dept. Agr. Colln., record published in "Insects of North Carolina"].

GROUP III

ACROCERA FASCIATA Wiedemann

Acrocera fasciata Wiedemann, 1830, Auss. Zweif. **2**:16 (Ga.).
A. fasciata; Johnson, 1915, Psyche **22**:201, fig. 3 (wing).
A. fasciata; Cole, 1919, Trans. Amer. Ent. Soc. **45**:51 (males only; fig. 33=*unguiculata!*)
A. nigrina of Cole and Johnson (as in Cole, fig. 35a). (♀).
A. fasciata; Emerton, 1890, Psyche **5**:404, fig. (♂, side view).

The species cannot be positively identified from Wiedemann's brief description, but I have followed past authors in linking the name with a common American species which has been reared from spiders and recorded in the literature a number of times (Emerton, 1890; Montgomery, 1903; Johnson, 1903, 1904, 1915). Cole (1919) repeated the published records, but his figure of the species (Fig. 33) is based on the female of another species (*unguiculata*) in which the venter is predominantly yellow.

There is some slight variation in the extent of color in the series of specimens before me, but it does not interfere greatly with the prevailing pattern which seems to be characteristic of the species, as shown in my figure 2 for the male and Cole's figure 35a for the female.

Males: Head and thorax black, shining, with short, appressed pale hair; propleura usually infuscated; humeri whitish yellow (chiefly black in McLean, N. Y. example); postalar calli chiefly black, but the posterior third and often the upper margin whitish-yellow; scutellum deep yellow, varying from entirely so or with only a narrow basal black mark to black with only the margin yellow. Abdominal segments 2-5 conspicuously banded (Fig. 2), that on segment four sometimes not reaching the sides, and appearing like a short and very broad median triangle. The sterna of the abdominal segments with broad, parallel sided black fasciae as noted in the key (Fig. 2a). Legs yellow, the claws and distal portion of last tarsal segment black. Of the five males before me, three have the veins of the wing (outside of the heavy costal margin) pale straw-yellow, one deep yellow, and one brown. Both of the latter were collected in the Black Mts., North Carolina, and the deeper color of the wing veins may be due to altitude. These same two specimens also showed the greatest extent of black areas on the abdomen. Length, 3-4.5 mm.

Females: much darker habitus than the males. Humeri and propleura consistently whitish yellow, but the postalar calli black except for the extreme tip, and the scutellum entirely black. Abdomen as figured by Cole in Fig. 35a, subject to slight variation in the size of the median triangle on segment four in the size and extent forward of the yellow on segment three. In one specimen (Oquossoc, Maine), there were small spots on the second segment also, opposite and narrowly separated from the anteriormost extent of the yellow areas on segment three. In another example (Bennington, Vt.), the basal black fascia on the third segment was continuous mesad with the median triangle of the fourth segment. With these slight exceptions, Cole's figure seems to afford an excellent means of quick recognition. The wing veins vary in color from yellow to brown, and the femora and tibiae are often browned. Length, 4-6 mm. Valves of the ovipositor long and acuminate, the apex a sharply acute angle.

Specimens examined*: CONNECTICUT: ♀, Darien, June 12, 1915 (C. W. Johnson). MASSACHUSETTS: 2♂, Framingham, June 19, 1915 (beating dead *Salix*) and Aug. 11, 1923 (beating dead limbs) (C. A. Frost). MAINE: ♀, Oquossoc, July 1, 1922 (C. W. Johnson). NEW HAMPSHIRE: ♀, Shirley Hill, June 17, 1911 (F. W. Grigg). NEW YORK: ♂, ♀, The Shack, McLean Res., June 21 (♀) and 28, 1924; 2♀, Ithaca, June 28, 1917 (H. Dietrich), and June 1, 1939 (P. I. Babiy); ♀, Newcomb, July 5,

1918. NORTH CAROLINA: 2♂, Black Mts., Aug. 21-Sept. 9, 1912 (Beutenmuller). VERMONT: ♀, Bennington, June 18, 1915 (C. W. Johnson).

* All New England specimens are from the Boston Society of Natural History, determined by Johnson and Cole, the males as *A. fasciata*, the females as *A. nigrina*, and so published by Johnson (1915, 1925) and by Cole (1919). The other specimens are from the Cornell University Collection.

ACROCERA NIGRINA Westwood

Acrocera nigrina Westwood, 1848, Trans. Ent. Soc. London **5**:97. (Ga.)
A. nigrina; Brunetti, 1926, Ann. Mag. Nat. Hist. (ser. 9) **18**:588.

In spite of Brunetti's notes on the type, I have been unable to associate any of my specimens with Westwood's name. According to Brunetti, the second vein (R_{2+3}) is entirely absent and the third vein (R_{4+5}) is forked, thus placing it without question in Group III in my analysis. Unfortunately, his notes do not include a mention of the appearance of the venter, but even considering both possibilities for the latter, his description of the dorsum of the abdomen is quite unlike any females now before me and is certainly not at all like *nigrina* of Cole, Johnson, et al. Brunetti writes as follows: "Abdomen practically wholly dark" (in key), and later "Abdomen dark brown; spots on fourth tergite elongate, narrowed on hind margin, well separated; fifth tergite practically all black with a narrow yellow hind margin." Obviously this does not agree with the prevalent conception of *nigrina* (as in Cole, 1919, Fig. 35a), which I believe to be the female of *A. fasciata*.

In fact, in all four groups, the only females which will fit Brunetti's notes are those of *A. bimaculata* Loew (cf. abdomen of *bimaculata* as figured by Cole, Fig. 32). Inasmuch as the latter is one of the most frequently encountered species of *Acrocera*, it would indeed be strange if Westwood had not had a specimen of it. Of course, *bimaculata* is supposedly distinguished by the apical rudiment of the second vein, but I have seen specimens in which that apical spur was so abbreviated that it could easily have been overlooked by both Westwood and Brunetti. Tentatively, I suggest that *nigrina* and *bimaculata* may be synonymous, but until its type can be studied with this in mind, the former name must be left unrecognized.

ACROCERA HUBBARDI Cole

Acrocera hubbardi Cole, 1919, Trans. Amer. Ent. Soc. **45**:58, fig. 31 (Ariz.)

The two females upon which Cole based his species were taken in the Santa Rita Mountains, and it is not impossible that they are examples of a Canadian or Transition Zone species with a wide range in northern and western United States and Canada. Two females, Edmonton, Alberta, July 10, 1920 [Univ. Mich., Mus. Zool.] and one female, Toronto, Ontario, 1896 [Hough Colln.], deposited at Field Museum agree fairly well with Cole's description and figure, notably with respect to the predominantly black venter. One female (Alberta) has a narrow yellow band with sinuate anterior border along the posterior margin of the second abdominal dorsum, but in the other two the yellow area is reduced to two very small and widely separated spots.

The three examples have been determined tentativly as *hubbardi* until such time as further specimens are available to check on its distribution.

ACROCERA CONVEXA Cole

Acrocera convexa Cole, 1919, Trans. Amer. Ent. Soc. **45**:53, fig. 29. (Calif.).

The species is included here solely on the basis of Cole's description and his excellent figure. From the latter it is obvious that it has the predominantly yellow type of venter, and it has been so included in my key. However, Cole associated with his male holotype from California a lone female from Spokane, Wash. I doubt if this is the female of *convexa*, for Cole says "venter black with few markings." If correct, that would place the specimen in another species as I conceive them, and for this reason I withhold recognition of the female of *convexa* until proper material makes a solution possible.

Acrocera hungerfordi, new species

Female: Predominantly black, only the humeri, upper edges and apices of the postalar calli (entirely white in one specimen), halteres, and fasciae on the third to fifth abdominal segments, white or yellowish white, the venter of the abdomen chiefly whitish-yellow, as noted in the second choice of couplet 6, and the pattern on the dorsum as in my figure 3, though in one paratype the second segment is entirely black. Squamae white. Legs extensively browned, in most cases only the coxae in part, the trochanters and narrow bases of the femora, and the knees broadly, yellow; claws and ends of last tarsal segment black. Veins of the wing distinct though pale yellow. Length, 4-5 mm.

Male: Like the female, except for yellow legs and different pattern on the dorsum of the abdomen, as shown in my Fig. 3a, the latter being very similar to that of the male of *A. fasciata*. It is best distinguished from *fasciata*, as are the females also, by the predominantly yellow venter of the abdomen (cf. separation in couplet 6). Length, 3 mm.

Holotype, ♀, Cheboygan Co., Mich., July 27, 1935 (Milton Sanderson) (Kans. Univ.). Allotype, Mauch Chunk, Pa., July 21, 1913 (Cornell Univ. Colln.). Paratypes: ♀, Cheboygan Co., Mich., Aug. 3, 1936 (H. B. Hungerford) (Kans. Univ.), and 2 ♀, Beulah, Mich., July 15, 1942 (C. W. Sabrosky; collected on dead twigs in old orchard) (Sabrosky Colln.).

Michigan: 7 ♀, Kewadin, July 17, 1943 (C. W. Sabrosky; on dead apple spurs) (Sabrosky Colln., Mich. State College).

The species is dedicated to Dr. H. B. Hungerford of the University of Kansas, who has taught and collected for many years in the Cheboygan County area and to whom the writer is deeply indebted for an inspiring start in entomology.

The species seems to have passed unnoticed in the confusion of names, the females probably being called *nigrina* and the males being included with

fasciata, although the lone male before me even bears a label for *A. bulla,* possibly a curatorial error. It was not until the species were segregated into groups, and were further divided on the character of the venter of the abdomen, that it was evident that one series of specimens was left nameless.

Since the lone male is not closely associated in distribution, I have chosen to select the holotype from the series of four females, in excellent condition, from northern Michigan.

Two different specimens have a short stub of vein R_{2+3} present at the normal point of origin of the vein, in one wing but not in the other. Such abnormalities are not at all uncommon in the wings of these flies.

A series of seven females collected in 1943 show some variation in the amount of yellow on the second abdominal segment and on the propleura, so that in couplet 13 it might be difficult to place certain specimens properly. *Acrocera* sp. (*obsoleta*?) is somewhat different with a broad hind marginal band on the second segment, interrupted mesad (Fig. 5), but *A. unguiculata* ♀ is quite close.

Of the seven, three agree with figure 3. Two others are essentially the same, the spots on the second segment a trifle larger and connected by a narrow yellow line along the margin of the segment. Two specimens, however, have the yellow spots more broadly connected so that the abdomen approximates the appearance of *A. unguiculata* as shown in figure 4.

In *unguiculata* the propleura is entirely and strikingly whitish-yellow; in this series of *hungerfordi,* on the contrary, the propleura is chiefly black, sometimes yellow on the dorsal fourth.

ACROCERA UNGUICULATA Westwood

Acrocera unguiculata Westwood, 1848, Trans. Ent. Soc. London **5**:98 (Ga.)
A. unguiculata; Brunetti, 1926, Ann. Mag. Nat. Hist. (ser. 9) **18**:588 (notes on type).
=*A. fasciata* of Cole, fig. 33 (♀ only).
=*A. obsoleta* of Cole in part, as in fig. 36 and 36a (♂ only).

I believe that Johnson and Cole erred in assigning the name *unguiculata* to a species in which vein R_4 (anterior branch of the third vein) and the anterior crossvein are absent. Brunetti indicates that the second vein (R_{2+3}) is absent, but runs Westwood's name in his key under "third vein forked," as opposed to "third vein simple." Other features in Brunetti's detailed notes, such as the appearance of the dorsum of the abdomen, and the "wholly very pale yellow" venter, indicate that *unguiculata* of authors is a species near *A. bulla* Westwood, and that the type of *unguiculata* is really a male specimen resembling the species called *A. obsoleta* in Cole's monograph (Cole, Fig. 36). Inasmuch as I have recognized two very similar species there, the problem is to decide if possible upon the proper use of the names *unguiculata* (as of Westwood, not of authors) and *obsoleta,* as to whether or not they are synonymous, or if distinct, which is which.

Van der Wulp's description of *A. obsoleta,* and his figure of the wing, indicate that *obsoleta* belongs in this group which lacks the second vein but in

which both branches of the third vein are present even though very pale or "obsolete" in appearance. It is also stated definitely that the venter is chiefly pale yellow, with the curved anterior crossbands of black. In the case of both *obsoleta* and *unguiculata,* therefore, the available information fortunately is definite enough to place the species in my Group III and among those species having predominantly yellow venter (cf. Fig. 4a). In both cases the description is apparently that of a male, from the color pattern of the abdomen. Neither Van der Wulp nor Westwood stated the sex of their types, and Brunetti said only that the genitalia of *unguiculata* were 'too concealed to be sure but appeared to be a male.'

Of the two forms which I have recognized in my key, the males of both will run to *obsoleta* in Cole's key, and his figures show that he considered both to be the same species. The name *unguiculata* was of course applied by Cole to a species in another group. In Brunetti's key, both species will run to *unguiculata,* allowing for an obvious inconsistency between key and notes on the color of the last tarsal segment.. As for the females of the two species, both will run to *fasciata* Wied. in Cole (♀ figured in Fig. 33) and to *subfasciata* Westwood in Brunetti's key. The former species has already been disposed of, and the latter belongs in another group having a complete second longitudinal vein present. One female specimen which I refer to *unguiculata* proper is shown in Figs. 4 and 4a.

Although Brunetti's notes leave much to be desired when it comes to separating these two closely related species, the wording of his description of the abdomen seems to make possible a reasonable inference as to which species Westwood had. Brunetti states: "Abdomen bright but pale orange-yellow; first segment extremely short, yellow; *second segment* dark brown basally and *broadly so at sides,* with a wedge-shaped median stripe reaching to middle of segment; *third segment more narrowly at sides,* and also a small triangular spot in middle of front margin, brown; *fourth segment* with a *rather small curved spot on each anterior corner* and a very small spot in middle of front margin brown; fifth segment (withdrawn) apparently all pale yellow." (italics are mine).

The gradation in the amount of black at the sides of segments 2-4 would apply only to the one species (Cole, Fig. 36a), for in the other (Cole, Fig. 36b) there is an extremely small spot of black on the sides of both the third and fourth segments. The phraseology thus appears to fix the identity of male *unguiculata.* Unfortunately there are no hints in the description of *obsoleta* which would enable one to infer its probable identity in like fashion. It may be a synonym of *unguiculata* or it may be a distinct species.

The five males recorded below have a remarkably uniform habitus, with only a slight variation in the size of the median triangles on the third and fourth segments, although in none of the specimens are they as large as in Fig. 36 of Cole. It may also be important to note that in each of the five males, the triangles on these segments are of approximately equal size, whereas in the next species, as far as my limited material is concerned, the median triangle on the fourth segment is much smaller or even absent.

Specimens examined: ILLINOIS: ♂, ♀, Argo, Aug. 29, 1915 (W. J. Gerhard), and ♂, Cary, Aug. 21, 1905 (W. J. Gerhard) [Field Mus. Nat. Hist.]; ♂, Evanston, Sept. 7, 1931 (A. R. Park) [Ill. Nat. Hist. Survey]. IOWA: ♂, Sioux City, Aug. 31, 1917 (A. W. Lindsey) [Ill. Nat. Hist. Survey]. MICHIGAN: ♂, Cheboygan Co., July 20, 1936 (R. L. Anderson) [Snow Colln., Kans. Univ.].

ACROCERA sp. (OBSOLETA V. d. W. ?)

=*Acrocera obsoleta* of authors, in part, as in Cole, 1919, figs. 36b and 36c (♂ only).
?*Acrocera obsoleta* Van der Wulp, 1867, Tijdschr. Ent. (ser. 2) **10**:139, pl. 3, fig. 17. (Wis.).

As already indicated in the discussion under the previous species, one cannot tell from Van der Wulp's description whether it applies to the species which I have called *unguiculata* or to the closely related species hitherto confused with it. It is possible that *obsoleta* is an absolute synonym of *unguiculata,* but it is equally possible that both names are valid, and apply to the two different forms which I have segregated from *obsoleta* of authors.

Because of this possibility, I see no advantage to be gained by describing the following specimens as a new species, inasmuch as it may some day be possible for someone to examine the type, if still in existence, and to associate the name definitely with one or the other segregate. Suffice it for the present to indicate the existence of a species other than *unguiculata* and to link it with its female sex. The female, like those of *unguiculata,* had previously been referred to *fasciata* by Cole and authors. Cole (Figs. 36b, 36c) has illustrated the males, and I have included here (Fig. 5) a sketch of the abdomen of the female which I associate with the species.

Of the two males cited below, the Michigan specimen has a very small black median triangle on the fourth abdominal segment, much smaller than that on the third segment, but in the Maine specimen there is no trace of a median triangle on the fourth segment. The former also has an entirely black scutellum, whereas in the latter specimen the scutellum is apically reddish.

Specimens examined: MAINE: ♂, Orono, Aug. 5, 1915 (A. P. Morse) (cited as *obsoleta* by Johnson, 1915, and Cole, 1919) (Boston Soc. Nat. Hist.). MICHIGAN: ♂, ♀, Cheboygan Co., Aug. 3, 1936 (Robert W. Forbes) (Snow Colln., Kans. Univ.).

ACROCERA sp.

One male was found which cannot be placed definitely. At couplet 6, the sternum has such broad yellow bands that one might perhaps select the second choice and pass to couplet 9, and thence to *Acrocera* sp. (*obsoleta*?). However, the specimen does not have the indented fifth abdominal segment or typical sternal pattern of the latter. It is also smaller, 2.75 mm. against 6 mm. of the robust *obsoleta*(?), but of course size is a weak criterion in Acroceridae.

The sternal pattern is best interpreted as the first choice of couplet 6, since the black basal area is fairly broad and not at all like that shown in Figure 4a. The dorsal pattern is somewhat like that figured by Cole (1919, Fig. 36), but the median spot on the third segment small, that on the fourth only a tiny obscure trace, and the lateral aspect as in Cole's figure 36b. Obviously this

male cannot be associated with male *fasciata* (cf. my figure 2). It may be the male of *A. hubbardi* (cf. notes on its possible range north and east) or it may be a hitherto unknown species.

MICHIGAN: 1 ♂, N. shore of Burt Lake, Cheboygan Co., July 18, 1943 (C. W. Sabrosky; on dead twig, six feet from ground, shady beech-maple forest) (Sabrosky Colln.).

GROUP IV

ACROCERA SPP. WITH GREATLY REDUCED WING VENATION

The species of this group present a difficult problem whose final solution must await much more material. I have seen only five specimens (3 ♂, 2 ♀), and these appear to represent two different species of males and two of females, with no hint as to how they should be associated, or even if they should be. To make matters worse, I cannot positively associate any published name with any of the four segregates. A few definite conclusions have been arrived at, and these will help to clear the way for future work:

1. *Acrocera bulla* Westwood belongs here, according to Brunetti's notes.

2. *Acrocera bulla* of authors (Johnson, Cole et al.) is an entirely different species, having complete wing venation (Group I). It has been described as *A. steyskali* new species.

3. *Acrocera fumipennis* Westwood belongs here, but the notes are too incomplete to be of any help in identifying it.

4. The species identified by authors (Fig. 37, 37a of Cole, 1919) as *Acrocera unguiculata* actually belongs here, but true *unguiculata* is a species of Group III and the name therefore does not apply in this problem.

5. One of the males referred to above is so striking that I have decided to describe it as new, and to identify the other two males tentatively as *A. bulla* (cf. discussion under the latter).

ACROCERA FUMIPENNIS Westwood

Acrocera fumipennis Westwood, 1848, Trans. Ent. Soc. London **5**:98 (Ga.)
A. fumipennis; Brunetti, 1926, Ann. Mag. Nat. Hist. (ser. 9) **18**:589.

I cannot associate the name with any specimens that I have seen, from the brief description and Brunetti's notes. The abdomen of the type is said to be entirely dark brown to black, which is different from any of the species known to me.

The species was not recognized by Johnson (1915) and Cole (1919), and both of these authors suggested that it might be merely a dark form of *A. unguiculata*. However, the latter is now known to be a species having both branches of vein R_{4+5} (third vein) distinct, whereas Brunetti reported that the type of *fumipennis* had the reduced type of venation (Group IV), the "third vein with anterior branch visible only at base" (Brunetti, p. 589). Thus *fumipennis* must be near *A. bulla*, and might or might not be that species.

Acrocera flaveola, new species

Male: Head black, the antennae and rudimentary mouth parts whitish yellow. Mesonotum golden yellow, with a black, posteriorly abbreviated median stripe flanked by two large round black spots (Fig. 6); humeri, propleura, and postalar calli entirey yellow to whitish; scutellum largely yellow, the sides broadly black and the base narrowly so; pleura black. Abdomen in dorsal view as in Fig. 6, golden yellow except for the base and sides of the second segment, the sides of the third segment, and small median spots at the anterior margins of segments three and four; venter pale whitish yellow, apparently entirely devoid of black marks except for narrow areas adjoining the second and third tergites. Legs entirely whitish yellow, including the last tarsal segment which is usually partially infuscated in *Acrocera* species, the claws brown with black tips. Halteres whitish yellow. Wings hyaline, veins pale, the venation like that of Fig. 37 in Cole (1919), the anterior branch of the third vein (R_4) not complete and yet with both basal and apical stubs which appear at certain angles of view to be connected by a crease in the wing in the position normally occupied by the vein. Squamae white with pale margins. Length, 3 mm.

Holotype, male, Juanita Island, Lake George, New York, July 26, 1920 (S. C. Bishop) [Cornell University Colln.]

The specimen had previously been determined by M. D. Leonard as *Acrocera liturata* Williston, and was recorded in the "List of the Insects of New York," p. 761, as "*liturata* (n. var.?)" However, the far western specimens which fit Williston's description of the striking color pattern of *liturata* have complete wing venation (Fig. 30 of Cole, 1919) and cannot be associated with the present individual.

ACROCERA BULLA Westwood (?)

Acrocera bulla Westwood, 1848, Trans. Ent. Soc. London **5**:98 (N. Y.).
A. bulla; Brunetti, 1926, Ann. Mag. Nat. Hist. (ser. 9) **18**:587.

Two males are recorded as *bulla* but with a question, because there are several doubtful points in the interpretation of Brunetti's notes. The specimen from Michigan agrees well in general, but Brunetti said the type was a female. Possibly this was a slip, as it certainly was when he wrote "third vein unforked, only the *upper* branch being visible," or possibly the female has a pattern not greatly unlike that of the male. At any rate, Brunetti wrote in his key: "Abdomen yellowish, extreme base and sides on basal half narrowly black; anterior margin of third segment narrowly black; a small basal spot on fourth segment." This corresponds so closely to the specimen figured here (Fig. 7) that I feel reasonably safe in recording it as *bulla*.

It is true that neither Westwood nor Brunetti mention any yellow areas on the mesonotum proper, as found in my specimens. Brunetti does say that "the type is now rather dirty," and that factor, or possibly the position of the pin, may have prevented a good view of any thoracic pattern. Brunetti also

states that the type measures 4½ mm., whereas the two males which I have are only 2½ mm. long, the smallest Acrocerids that I have seen.

The male from Massachusetts shows a slightly greater proportion of yellow than the specimen used for the figure, though retaining the same fundamental pattern. In addition to the posterior yellow area, each anterior angle of the thorax has an orange spot which includes the humerus and extends a short distance posterior to it, thus accentuating the appearance of three short and broad stripes which have merged to form a broad discal black spot which is both anteriorly and posteriorly tridentate. The yellow on the second abdominal segment is more extensive, and the basal fascia on segment three has become discontinuous, the lateral black areas not connected with the median spot. Only traces remain of the median and lateral spots on the fourth segment.

Specimens examined: MICHIGAN: ♂, Cheboygan Co., July 4, 1935 (H. B. Hungerford) [Kans. Univ.]. MASSACHUSETTS: ♂, Sharon, July 26, 1909 (J. A. Cushman) [Boston Soc. Nat. Hist.].

ACROCERA sp. (females of Group IV)

Two females from Michigan: Manistee, July 8, 1941 (C. W. Sabrosky) and Agricultural College, Aug. 26, 1891 (G. C. Davis) [Mich. State College Colln.], cannot be definitely determined beyond being assigned to this group because of their reduced type of wing venation. Both have an entirely black thorax with no indication of yellow areas. In both the abdomen is black on the basal half, with irregular yellow areas on the posterior portions of segments three and four, as in Fig. 37a of Cole (1919), although neither agrees exactly. The limits of the abdominal pattern may well be sufficiently variable to include these slight deviations. It is possible that these are the females of *A. bulla*, though one cannot overlook the possibility, especially with few specimens, that other species are concerned and that other combinations of males and females remain to be discovered.

One female, College Station, Texas, April 8, 1943 [Texas A. & M. College Colln.], length 4.5 mm., has an entirely black thorax, only the tips of the humeri pale, and a predominantly orange-yellow abdomen whose dorsum is almost identical in appearance with that of the male of *A. flaveola* (cf. Fig. 6). A cursory glance suggested that the specimen was probably a male of the species *unguiculata* or *obsoleta*(?). In view of the color pattern, it was therefore surprising to find that it was a female, and further that it had the reduced type of wing venation with vein R_4 and the r-m crossvein entirely absent, not even a streak in the wing membrane marking their position. Whether the present example is the female of *A. flaveola*, or whether it represents still another species, is unknown. Obviously, many more specimens of Group IV will have to be discovered before the relations of the males and females can be clarified.

MICHIGAN STATE COLLEGE,
EAST LANSING, MICHIGAN.

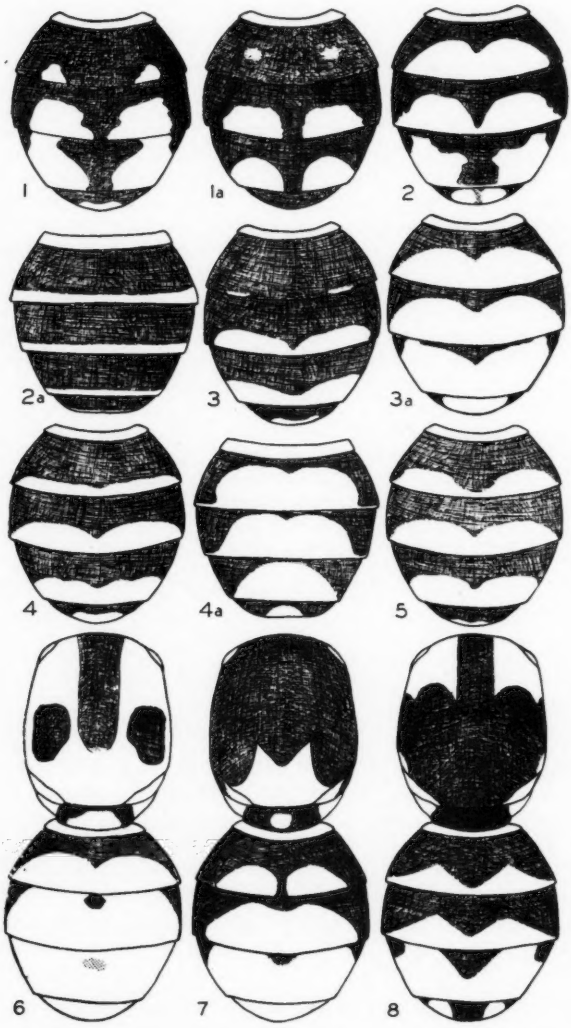

PLATE 1, Figs. 1-8. Diagrammatic color patterns of *Acrocera* species. Figs. 2a and 4a show the abdomen in ventral view; all others show the dorsal aspect. 1, *A. steyskali* ♂; 1a, *A. steyskali* ♀; 2, *A. fasciata* ♂; 2a, *A. fasciata;* 3, *A. hungerfordi* ♀; 3a, *A. hungerfordi* ♂; 4, *A. unguiculata* ♀; 4a, *A. unguiculata;* 5, *A. sp. (obsoleta?)* ♀; 6, *A. flaveola* ♂; 7, *A. bulla* ♂; 8, *A. subfasciata* ♀.

A Preliminary List of the Mosquitoes of Indiana

John W. Hart[1]

Although the first record of a mosquito from Indiana was published in 1827, when Say described *Culex musicus* [=*Psorophora ferox* (Humb.)], only four additional species appear to have been recorded from the state in the intervening 116 years — all by Dyar (1922). In the yearly reports on Indiana insects which Prof. J. J. Davis presented before the Indiana Academy of Science and which were published in the Proceedings of that organization from 1928 to 1937 the important areas of the state troubled by mosquitoes were noted but no specific records were included.

During the academic year of 1941-1942 the author prepared a manuscript entitled, "Preliminary Studies of the Mosquitoes of Indiana,"[2] based upon specimens which he collected during 1941 and additional material in the Entomological Collection of Purdue University. In July and August, 1942, he was employed for ten weeks with the United States Public Health Service in mosquito survey and malarial control work in the vicinity of army camps and defense industrial areas in Indiana. Records of specimens collected and/or determined, mostly from light traps, during this time have been combined with the records from the manuscript of the "Preliminary Studies" to form the following list of 24 species now known from Indiana.

Records are listed by counties only, except that more specific localities are also given, in parenthesis, for some of the specimens taken during July and August, 1942. Collectors are indicated by initials, as follows:

B.E.M.—B. Elwood Montgomery
G.E.G.—George E. Gould
G.S.R.—George S. Ryan
I.C.B.—Ivan C. Brooks
J.M.A.—John M. Amos
J.W.H.—John W. Hart
P.U.S.—Purdue Univ. Student Collection

1. *Psorophora ciliata* (Fabricius, 1794). Kosciusko (Lake Winona, E. B. Williamson – Dyar, 1922); Lawrence, June 3, July 11, 21, 27, Aug. 20, 1934, Aug. 28, 1935, J.M.A.; Marion (Fort Harrison), Aug. 4, 1942, J.W.H.; Jefferson, July 18, 1942, J.W.H.; Tippecanoe, June 23, 26, 1941, G.E.G.; LaPorte, Sept. 19, 1941, P.U.S.; Vigo (West Terre Haute), July 17, 1942, (Terre Haute), Aug. 31, 1942, J.W.H.; Warrick, June 26, 1937, J.M.A.

2. *Psorophora columbiae* (Dyar et Knab, 1906). Lawrence, July 21, 1934, J.M.A.; July 15, 1941, J.W.H.; Vigo, Aug. 31, 1942, J.W.H.

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1 Now serving as Second Lieutenant in the Army Medical Corps.

2 A thesis prepared under the direction of Prof. B. Elwood Montgomery, and submitted to the faculty of Purdue University in partial fulfillment of the requirements for the degree of Bachelor of Science in Agriculture, May 1942. Records from this thesis are published by permission of the Dean of the School of Agriculture.

3. *Psorophora cyanescens* (Coquillett, 1902). Lawrence, numerous adults collected or reared, June 13-Aug. 31, 1942, J.W.H.

4. *Psorophora ferox* (Humbolt, 1820). Jackson, Aug. 28, 1942, J.W.H.; Clark (Jeffersonville), July 18, 1942, J.W.H.; Knox, July 12, Aug. 14, 1937, J.M.A.; Lawrence, May 27, 1934, J.M.A.

5. *Psorophora horrida* (Dyar et Knab, 1908). Lawrence, July 12, 1941, J.W.H.; Tippecanoe, June 2, 1933, J.M.A.

6. *Psorophora Howardii* Coquillett, 1901. Jefferson, Aug. 18, 1941, J.W.H.; Knox (Vincennes), June 14, 1942, J.W.H.

7. *Psorophora varipes* (Coquillett, 1856). Knox, May 25, 1937, J.M.A.

8. *Aëdes aegypti* (Linnaeus, 1762). Knox, July 1, Aug. 8, Sept. 14, 15, 16, 18, 1937, J.M.A., (Vincennes), June 1942, J.W.H.

9. *Aëdes canadensis* (Theobald, 1901). Tippecanoe, April 1942, I.C.B. and J.W.H.

10 *Aëdes sticticus* (Meigen, 1838). Knox, May 24, 25, 1937, June 7, 1935, J.M.A.; Lawrence, July 10, 1935, J.M.A.; Tippecanoe, May 22, 1936, June 2, 1933, J.M.A.; Sept. 26, 29, Oct. 9, 1941, J.W.H.; Jefferson, July 18, 1942, J.W.H.

11. *Aëdes triseriatus* (Say, 1823). Jackson, Aug. 28, 1942, J.W.H.; Knox, June 22, July 1, Aug. 14, 1937, J.M.A.; Lawrence, June 3, Oct. 3, 1935, J.M.A.

12. *Aëdes trivittatus* (Coquillett, 1902). Knox, Sept. 16, 1937, J.M.A.; Lawrence, many specimens from May 27 to Oct. 1, 1942, J.W.H.; Orange, June 10, 1935, J.M.A.; Tippecanoe (Lafayette, July 21, 1916, J. J. Davis-Dyar, 1922); Warren, Oct. 11, 1938, J.M.A.

13. *Aëdes vexans* (Meigen, 1820). There were more than 225 specimens from the state in the collections studied. The collection dates ranged from May 11 to Oct. 20. The records included the following counties: Clark, Fulton, Jackson, Jasper-Pulaski (game preserve), Jefferson, Knox, LaPorte, Lawrence, Marion, Steuben, Tippecanoe, Vigo, Warren, Warrick and Wells.

14. *Theobaldia inornata* (Williston, 1893). Orange, Oct. 2, 1941, P.U.S.; Tippecanoe, Sept. 10, 1941, P.U.S.; Vigo (West Terre Haute), Aug. 25, 1942, J.W.H.

15. *Mansonia perturbans* (Walker, 1856) Marshall (Lake Maxinkuckee, W. B. Evermann – Dyar, 1922); Vigo (Terre Haute), Aug. 31, 1942, J.W.H.

16. *Orthopodomyia signifera* (Coquillett, 1896). Marion (Fort Harrison), Aug. 22, 1942, J.W.H.

17. *Culex apicalis* Adams, 1903. Steuben, Sept. 22, Oct. 22, 1941, G.S.R.; Tippecanoe, Sept. 20, 26, 1941, J.W.H.

18. *Culex erraticus* (Dyar et Knab, 1906). Clark (Charlestown), July 19, 1942, J.W.H.; Marion (Fort Harrison), July 22, 1942, J.W.H.; Vanderburg (Evansville), Aug. 19, 1942, J.W.H.

19. *Culex pipiens* Linnaeus, 1758. Clark, July 26, 1937, B.E.M.; DeKalb, Aug. 28, 1941, J.W.H.; Marion, Aug. 19, 1928, C. F. Adams; Tippecanoe, Mar. 2, Apr.-Aug. 9, 1937, J.M.A.; Sept. 20, 20, 1941, J.W.H.; Nov. 19, Dec. 22, 24, 1934, J.M.A.

20. *Culex restuans* Theobald, 1901. Clark (Jeffersonville), Aug. 25, 1942, J.W.H.; Marion (Fort Harrison), Aug. 10, 1942, J.W.H.; Randolph, Sept. 29, 1941, J.W.H.; Steuben, July 27, 1941, G.S.R.; Tippecanoe, Sept. 20, 26, 1941, J.W.H.

21. *Culex tarsalis* Coquillett, 1896. Tippecanoe, Sept. 20, 26, 1941, J.W.H.

22. *Uranotaenia sapphirina* (Osten-Sacken, 1868). DeKalb, Aug. 21, 1941, J.W.H.; Steuben, July 27, 1941, G.S.R.; Vigo (Terre Haute), Aug. 17, 1942, J.W.H.

23. *Anopheles punctipennis* (Say, 1848). DeKalb, Aug. 28, 1941, J.W.H.; Knox, Sept. 11, 1937, J.M.A.; Lawrence, June 17, 1935, J.M.A.; July 18, 1941, J.W.H.; Steuben, July 27, 1941, G.S.R.; Vigo (Terre Haute), Aug. pecanoe, Sept. 20, 24,, Oct. 5, 1941, J.W.H.; Nov. 19, 28, 29, Dec. 3, 29, 1934, J.M.A.

24. *Anopheles quadrimaculatus* Say, 1824. Knox, Aug. 14, 1937, J.M.A.; LaPorte, July 21, 1938, P.U.S.; Marshall (Lake Maxinkuckee, W. B. Evermann-Dyar 1922); Tippecanoe, Sept. 20, Oct. 4, 12, 1941, J.W.H.; Nov. 1, 1941, P.U.S.

Contributions to the Osteology of the Skull of the Amphisbaenidae*

Rainer Zangerl

1. Introduction

The remarkable worm-like reptiles of the family Ampisbaenidae have long attracted the attention of naturalists. Some time ago Mr. Arthur Loveridge kindly suggested to the writer that he examine the skeleton of a tiny amphisbaenid from East Africa, with the remark that there was little known about the osteology of these animals. Upon reviewing the literature it was found that there were only three articles dealing specifically with the skeleton of the amphisbaenids. In 1853 Gervais published his "Recherches sur L'ostéologie de plusieurs espèces d'Amphisbènes" in which he described and figured the skulls of *Amphisbaena fuliginosa, Blanus cinereus, Lepidosternon microcephalum* and *Trogonophis wiegmanni*. In 1884 von Bedriaga presented a rather accurate report on the skull of *Blanus cinereus* (under the name of *Amphisbaena cinerea*); and Cope, in 1892, described and figured the Floridan species *Rhineura floridana*.

Von Bedriaga alone attempted to work out the brain case of these animals; the other papers deal primarily with the surface bones of the skull. Due to the very small size of the material and the lack of modern optical equipment, these authors could not achieve the degree of accuracy desirable for morphological comparison. It is interesting to read Gervais' discussion of the systematic position of the amphisbaenids and then von Bedriaga's views on the same question. Both authors mention affinities between the amphisbaenids and the amphibians on the one hand and the mammals (insectivores) on the other. Furthermore they agree that the amphisbaenids can be classified neither with the "Lacertilia" nor with the "Ophidia" and that they should be set apart to occupy a natural systematic unit equal to those of the lizards and snakes. In principle they agree with Gray (1841) who created a separate order, Amphisbaenia.

These statements appear rather incredible in the light of the fact that more recent morphologists express no doubts regarding the systematic position of the amphisbaenids either as "a superfamily of the suborder Sauria" (Camp, 1923), or as "an infraorder of the suborder Lacertilia" (Romer, 1936). It was hoped, therefore, that an adequate variety of material would furnish sufficient evidence to correct some of the statements in the older literature and would include forms primitive enough to verify the lacertilian origin of these strange animals.

* Contribution from the Department of Biology, University of Notre Dame, Notre Dame, Ind.

In the course of my study it became increasingly clear, however, that the conclusions of Gervais and von Bedriaga had some basis; there is strong evidence that the amphisbaenid skull is neither a highly specialized derivative of the lizard cranium, nor that it can have originated from the ophidian skull. It seems to be a "conditio sine qua non" that embryological material[1] be investigated, prior to final decisions concerning the proper place in the system to be occupied by the amphisbaenids.

The material[2] underlying the present account consists of the following genera and species:

M.C.Z.		Locality
2154	*Amphisbaena fuliginosa* Linnaeus	South America, no other data
7799	*Amphisbaena fuliginosa* Linnaeus	near Riobamba, Ecuador
.....	*Amphisbaena ewerbecki* Werner	Tanganyika Territory
.....	*Amphisbaena ewerbecki* Werner	Tanganyika Territory
7936	*Amphisbaena cubana* Peters	Cuba, no details
31523–4	*Bipes biporus* Cope	La Paz, Lower California
.....	*Geocalamus acutus* Sternfeld	Kenya Colony
6001	*Trogonophis wiegmanni* Kaup	no locality
4337	*Rhineura floridana* Baird	Florida, no other data
42389	*Monopeltis c. capensis* Smith	Transvaal
CM. 9025	*Leposternon microcephalum* Spix	Brazil: Rio de Janeiro; Theresopolis; Fazenda Posse.
CM. 9021	*Leposternon microcephalum* Spix	same locality

The writer is greatly indebted to Dr. Thomas Barbour, Director, and to Mr. Arthur Loveridge, Curator of Reptiles and Amphibians of the Museum of Comparative Zoology, Cambridge, Mass. for the opportunity to study this valuable material. My sincere thanks also go to Mr. Loveridge for his kind advice and helpful suggestions throughout the preparation of this report. I am deeply grateful to Dr. A. S. Romer and to Dr. E. C. Case for their willingness to discuss the various problems and to Mr. Karl P. Schmidt, Chief Curator of the Department of Zoology, Chicago Natural History Museum, for reading the manuscript and offering for study a young specimen of *Leposternon microcephalum*, which is of great interest because of its immature state of skull ossification. This specimen was examined after the completion of the manuscript. It proves correct the writer's interpretation of the morphology of the amphisbaenid brain case.

2. The General Morphology of the Amphisbaenid Skull

The general appearance of the amphisbaenid skull is not unlike that of an insectivore because of the forward position of the articular joint of the lower jaw and the impressive size of the brain enclosure which lacks all kinds of lateral arcades so characteristic of the lacertilian skull. The cranium surpasses the facial part of the skull in size and reaches its greatest width in the region of the otic capsulae. The shape of the facial portion varies greatly with the species; in extreme cases it may be modified to represent a shovel-shaped digging device (e.g., in *Monopeltis* and *Rhineura*). The longitudinal axes of the cranium and the facial portion of the skull do not form a straight line; the facial region is bent downwards at various angles.

The interpretation of the elements that line the floor and the side walls of

1 Embryological material is not available now; a study of the embryology of the skeletal system of the Amphisbaenidae will be undertaken by the writer when embryos can be obtained.

2 All specimens (except 2 specimens of Leposternon) belong to the Museum of Comparative Zoology, Harvard University, Cambridge, Mass.

the cranial cavity encounters serious obstacles. In adult individuals the bones of the occipital and otic regions are completely co-ossified, leaving no traces of sutures between them. This situation renders difficult the recognition of homologies among the remaining bones of the brain case.[3] The few authors who have studied the amphisbaenid skull accordingly disagree as to the morphological identity of some of the elements. The chondrocranial development of both the lizard (Gaupp, 1900; Rice, 1920) and the snake skulls (Parker, 1878; Peyer, 1912) have now been worked out in detail so that a new basis for comparison is available.

The lizard chondrocranium still possesses remains of the original sphenolateral side walls of the brain case in the form of supraseptal cartilages and a delicate framework of bars, the taeniae marginales, but it is not particularly suitable for comparison with the amphisbaenid cranium because of its extremely tropibasic character. The great increase in size of the orbits probably resulted in the gradual approximation of those parts of the sphenolateral cartilages that formed the inner walls of the orbits until they fused in the sagittal plane to form the septum interorbitale. The anterior portion of the cranial cavity that originally lay between the orbits became displaced dorsad.

The snake and amphisbaenid skulls, on the other hand, having orbits of moderate or small size, have retained the primitive distribution of cranial cavities (Fischer, 1900). The most anterior portion of the cranial cavity, containing the olfactory lobes, lies between the inner walls of the orbits and immediately dorsal to the roof plates of the mouth. It is in direct axial alignment with the cavum nasi.

In contrast to the condition in lizards the orbito-temporal region of the snake chondrocranium appears to have lost its primordial side walls. Parker (1878) claims to have found pairs of alisphenoids[4] as well as orbitosphenoid cartilages in *Tropidonotus natrix*. Peyer (1912) could not discover the presence of such elements in *Vipera aspis;* but there is indirect evidence (first postulated by Gaupp (1902) for *Tropidonotus* and later confirmed by Peyer (1912) for *Vipera*) that cartilaginous, primordial side walls of the orbito-temporal region were present in ancestral snakes. Their location is indicated by the position of the dura mater and the exits of the brain nerves through this membrane.[5] The following interpretation of the amphisbaenid brain case was arrived at partly by comparison with the ophidian skull and its development.

The floor of the brain case consists of three medial elements. The basioccipital is a large plate, bulging somewhat ventrad. Its anterior extent is indicated in most forms by a distinct transversal suture. The occipital condyle is relatively large and double knobbed. Whether or not the exoccipitals take part in the formation of the condyle cannot be decided and von Bedriaga (loc. cit.), who examined a very young specimen of *Blanus,* does not mention this

3 A study of the embryonic brain case will no doubt solve the problem.

4 The elements, labeled "alisphenoids" by Parker are ossifications in the region of the pila antotica. They are therefore constituents of the primordial side walls of the brain case and are thus pleurosphenoids (Goodrich, 1930).

5 For further detail concerning this information see Gaupp (loc. cit.).

point. Gervais (1853) remarks that, in *Trogonophis* at least, he could make out the extent of the basioccipital and according to him the exoccipitals do form the lateral parts of the condyle, much as in turtles. The latter statement could be confirmed in the case of *Leposternon* (see description, page 447).

In front of the basioccipital there is an even larger bone, shaped somewhat like a spearhead (Figs. 1 and 10). On its dorsal surface there are two low, longitudinal bony walls which, together with the flat, central portion of the element, form a channel for the reception of the brain (Fig. 2).[6] Laterally, just in front of the suture between this plate and the basioccipital, are the canals for the internal carotids (Fig. 1). A sella turica is not visible; there is not even a shallow depression to indicate the position of the hypophysis.[7] Von Bedriaga (1884), Williston (1917) and Gilmore (1928) consider this spearhead-shaped element to be the basisphenoid. Gervais (1853) refers to it as the "sphénoide." In snakes the basisphenoid is fused with the parasphenoid; the shape of the latter is largely determined by the course of the trabeculae baseos cranii, which, posteriorly embrace the fenestra hypophyseos; in front of this opening they lie parallel, side by side, but do not fuse to become a trabecula communis as in lizards. The parasphenoid closes the fenestra hypophyseos ventrally, and, towards the front, appears drawn out into a slender rostrum that lies between the parallel portions of the trabeculae. On either side of the posterior margin of the hypophyseal opening there is a notch for the A. carotis interna, which later on marks the approximate limit between the para- and basisphenoid (Peyer, 1912). The spearhead-shaped plate in the brain case of amphisbaenids, in particular of *A. fuliginosa* (Figs. 1 and 12) seems to resemble very much in shape as well as in construction the basi-parasphenoid of snakes. Roughly the notches for the passage of the A. carotis interna would indicate the border of the basisphenoid posteriorly and the much larger parasphenoid in front. The opinion that the large, spearhead-shaped bone in front of the basioccipital should be considered as a fused basi-parasphenoid, was found to be correct. A young specimen of *Leposternon microcephalum* shows very clearly the sutures between basisphenoid and basioccipital, and between the basisphenoid and the parasphenoid. The latter suture runs, as was previously assumed, between the openings for the internal carotids (see description page 447 and Fig. 17). It was assumed that the transversal suture extending between the elements "X" in the various forms described is the one separating the basioccipital from the basi-parasphenoid. On the basis of additional information gained from *Leposternon* it appears likely, however, that this is true only in such forms as

6 Von Bedriaga's description and illustration suggest that he considered the longitudinal bony walls on the dorsal surface of this element as alisphenoids (pleurosphenoids). In *Trogonophis* they form a large part of the side walls of the brain case, but in *A. ewerbecki*, of which serial sections through the head are available, these walls appear merely as low crests on what is here considered the basi-parasphenoid and there is no indication that they might represent separate bones. Von Bedriaga's paroccipital processes are here considered to be pleurosphenoids (see below).

7 An examination of the pituitary from serial sections through the head of *A. ewerbecki* revealed that the shape of this organ is broad and flat, somewhat as in amphibians.

Amphisbaena fuliginosa and *Geocalamus acutus,* whereas e.g. in *Monopeltis c. capensis* the suture remaining in the adult condition seems to be the one between basioccipital-basisphenoid and the parasphenoid. Thus there is evidence to believe that the sutures in question are not homologous in all amphisbaenids. The parasphenoid is wider and shorter than in snakes and does not carry a rostrum; in its place there is a slender element, here interpreted as a presphenoid (see below).

Dorso-laterally attached to the widest part of the basi-parasphenoid are the fused bones of the otic capsules. As in amphibians these organs are very large; their longitudinal diameter amounts in some forms to about one-third of the skull length. The foramen ovale is correspondingly large and closed by a slightly oval stapedial foot plate. The columellar part of the stapes is very short. There is a cartilaginous (sometimes in part bony) extracolumella, which stands approximately at a right angle to the stapes. It lies in a shallow groove on the outer face of the quadrate and attaches itself to a ligament that covers a spongy substance (modified muscle tissue?) on the lateral surface of the mandible. Versluys (1936) and Camp (1923) describe and figure this peculiar condition. In Fig. 18c the entire apparatus of *Geocalamus acutus* is shown in situ in a photograph.

Lateral to the basisphenoid-basioccipital suture and medial to the foramina ovalia there is a pair of superficial bony flakes for which the writer finds no homologon among reptiles. In the present report these structures are referred to as elements "X." In *Monopeltis* the writer believes to have noticed, besides well defined elements "X," a second pair of ossicles (elements "Y") located anterior to the foramina ovalia. Gervais (1853) refers to these structures (elements "X") as follows(speaking about the shape of the basiparasphenoid in *A. fuliginosa*): ". . . des quatre autres bords du même os, les deux latéraux sont un peu échancrés pour loger les roches. . . ." Williston (1917) noticed the elements in *A. alba* and labeled them "paroccipitals." In *Blanus,* where the basioccipital and basisphenoid are totally fused, the elements "X" are neither mentioned nor figured by von Bedriaga (1884). Most likely they are fused to the large medial plate as is the case in *Rhineura* (Fig. 15) where only faint outlines are visible. Von Bedriaga, who dissected an immature specimen, describes proötic, epiotic and opisthotic bones as well as distinct exoccipitals (op. cit. Figs. 11 and 12). Judging from von Bedriaga's description and illustrations, it is quite safe to believe that the elements "X" represent none of these bones. It is difficult even to guess at the possible nature of the ossicles in question. Discussing the numerous amphibian resemblances of the amphisbaenid organization, one might be tempted to compare these flakes with the so-called opercula of the amphibian ear region.

Von Bedriaga reports that one of the otic bones, the proötic, possesses a rather long anterior process (paroccipital process) which, to a minor degree, forms the side wall of the brain case. This projection was noticed in every one of the forms examined (see the side views in the various illustrations); in some of them, e.g., in *Rhineura* and *Monopeltis,* it is extremely large (Figs. 15 and 16). In both species the anterior rim of the foramen ovale is pierced

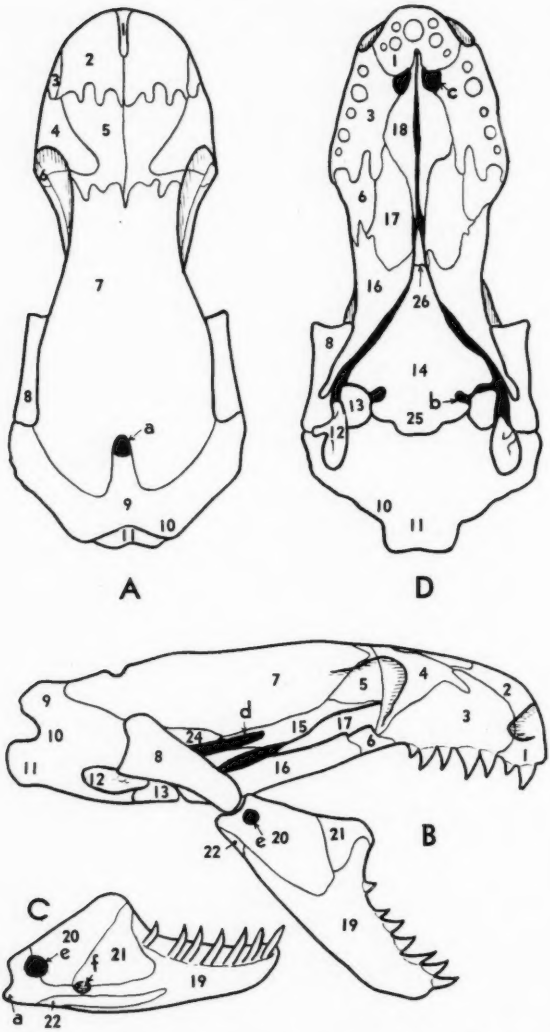

Fig. 1. Skull of *Amphisbaena fuliginosa* (spec. "A") A, dorsal view; B, lateral view; C, medial view of mandible; D, ventral aspect. About 6 times natural size. See also Fig. 12.

by a small canal the position of which can well be compared with that of the facial foramen. Von Bedriaga's paroccipital process is connected to the basisphenoid by a vertical pillar anterior to the canal afore-mentioned. Since it is unusual for the proötic to take part in the formation of the side wall of the brain case to the extent seen in *Rhineura* and *Monopeltis*, it was considered possible that the elements under consideration might be a separate unit, merely fused to the bones of the otic region. The general location and topographic

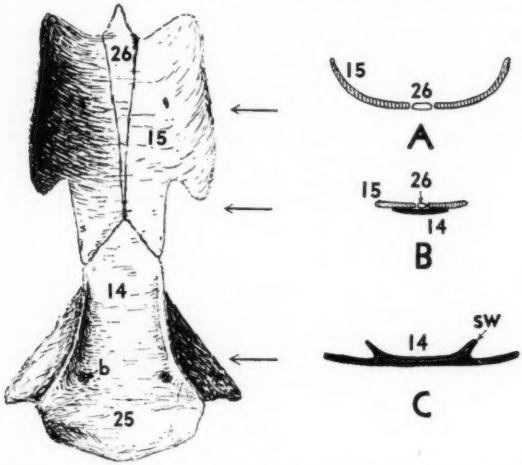

Fig. 2. Floor of the brain case of *Amphisbaena fuliginosa* (spec. "A') seen after the parietal was removed.

KEY TO THE SYMBOLS USED IN THE ILLUSTRATIONS

1 Premaxilla
2 Nasal
3 Maxilla
4 Prefrontal
5 Frontal
6 Ectopterygoid
7 Parietal
8 Quadrate
9 Supraoccipital
10 Exoccipital region
11 Basioccipital
12 Stapes
12' Extracolumella
13 element "X"
14 Parasphenoid
15 Orbitosphenoid
16 Pterygoid
17 Palatine
18 Vomer
19 Dentary
20 Supraangular
21 Coronoid
22 Angular
23 semi-circular canals
24 Pleurosphenoid
25 Basisphenoid
26 Presphenoid

a space left by removal of cartilaginous part of the anterior supraoccipital prong.
art. aricular (not distinct).
b foramen for internal carotid.
c foramen leading to the Jacobson's organ.
d foramen immediately lateral to Gasserian ganglion.
e opening piercing the mandible.
f mandibular foramen.
sn nasal septum.
sw lateral, longitudinal side walls on the dorsal surface of the basi-parasphenoid.

relationship of this bone to the adjoining elements strongly suggest that it is an ossification of the primordial side wall of the brain case, a pleurosphenoid (Goodrich, 1930).[8] If this interpretation is correct, we have to assume the orbito-temporal walls of the amphisbaenid chondrocranium to be at least as extensive as in salamanders.

The examination of a juvenile skull of *Leposternon* confirmed the writer's opinion that von Bedriaga's paraoccipital processes are not merely anterior projections of the proötics, but separate elements (pleurosphenoids) which totally co-ossify with the proötics (see description page 447).

A third medial bone, lying in front of the basi-parasphenoid, is evident in *A. fuliginosa*.[9] It is long and slender and laterally embraced by a pair of large plates the outer edges of which are curved dorsad to join the parietal and the frontal margins (Figs. 1, 2).[10] The medial bone overlaps dorsally the tip of the plate here considered as the parasphenoid. It is most likely an ossification of the trabeculae which might be united in front as in lizards (trabecula communis) and would represent a presphenoid. The interpretation of the lateral leaves as orbitosphenoids (v. Bedriaga, loc. cit.) is probably correct.

There is a long and narrow opening in the side wall of the amphisbaenid skull. Ventrally it is bounded by the upper edge of the lateral, longitudinal bone wall of the basi-parasphenoid (Fig. 2, sw); posteriorly, and in part dorsally, by the pleurosphenoid and dorso-anteriorly by the orbitosphenoid. This slit-like opening lies directly outside the Gasserian ganglion, which is greatly elongated.

Dorsally the cranial cavity is roofed by a large plate consisting of the medially fused parietals, and by the supraoccipital, which is mostly covered by the posterior parietal lobes. As a rule there is a deep notch in the rear margin of the parietal, filled by a tooth-shaped prong of the supraoccipital, the tip of which may remain cartilaginous in the adult (Figs. 1-a and 7K).[11] The lateral edges of the parietal plate are curved downwards to meet the pleuro- and orbitosphenoids.

The frontals form a solid bone ring around the olfactory lobes of the brain. Their aboral edges attach themselves dorsally to the parietal, laterally to the orbitosphenoids and ventrally to the tip of the presphenoid. In snakes (Peyer, 1912) the frontals form a similar ring around the anterior portion of the cranial tube but their medio-ventral suture lies dorsal to the parasphenoid rostrum. Similar conditions are reported to exist in salamanders (Wiedersheim, 1877).

The nasal cavities are separated in front by a sagittal lamella of the pre-

8 For von Bedriaga's interpretation of the alisphenoids (pleurosphenoids) see footnote 6.

9 In one of the specimens the parietal plate was removed.

10 Von Bedriaga labeled the medial element parasphenoid, the lateral ones orbitosphenoids.

11 During the process of maceration of a skull this cartilaginous portion is often removed, leaving a hole in the roof of the cranium.

maxillary, further back by a cartilaginous septum nasi and the septomaxillaries, which cover the Jacobson's organs. In addition the vomers carry low, vertical crests on their dorsal sides that help to separate the nasal cavities (Fig. 7A). The elements that constitute the surface of the snout vary greatly in their extent and topographic relationships. Riding on the lateral surface of each frontal there is a prefrontal flake that makes up the anterior face of the orbital depression. Williston (1917) found in *A. alba* a tiny postorbital element directly behind the prefrontal. None of the forms under present observation possesses this bone.

The quadrates are long bones equipped with joint surfaces on both ends. Proximally they are attached to lateral, knob-shaped projections of the otic regions, from which they extend forward and downward. The shape of the quadrates is similar to that of certain reptilian phalanges. Dorsal to the point where the quadrates originate there are thin superficial bones in various stages of reduction in the material studied. Von Bedriaga (1884) considers them to be squamosals because of the similarity of their position to that of these bones in the snake skull.

The roof of the oral cavity is primarily supported by the pterygoids, which are posteriorly attached to the medial surfaces of the quadrates. In front they are relatively wide horizontal plates joining the palatines and ectopterygoids or maxillae in various fashions in the different forms. The maxillae are quite short and each carries a row of teeth of slightly unequal size. Between the aboral ends of the maxillae and the pterygoids there are usually well developed ectopterygoids. The central part of the roof of the mouth is made up of the palatines and vomers.[12] The former are thin flakes, located ventral to the orbitosphenoids (Fig. 7B and C); their inner and outer edges are curved ventrad to form the roof of the internal nares. The vomers are long and slender bars that sometimes carry lateral wings to connect with the medial edges of the maxillae.

The unpaired premaxilla always bears a strong medial tooth and a variable number of lateral ones. Behind the premaxilla is a pair of openings leading to the Jacobson's organs. A sagittal lamella of this bone extends to the roof of the snout.

The dentition is usually pleurodont; only in *Trogonophis* (and allied genera), as Gervais (1853) points out, is it distinctly acrodont.

The morphology of the lower jaw has been well characterized by Gilmore (1928): "The mandible especially undergoes the greatest modifications. The angular bone is chiefly developed on the internal side of the ramus, and the splenial is very small. The coronoid is large and subtriangular, and is overlapped from behind by the surangular on the external face of the ramus. Meckel's groove is closed." The writer has not been able to find a distinct splenial (opercular) in any of the forms examined. On the photograph (Fig. 18, a) a number of longitudinal lines are noticeable on the lingual surface of

12 The term "vomer" is here used in preference to "prevomer" (Parrington and Westoll, 1940).

the anterior prong of the angular. Since adjoining skull plates of all amphisbaenids tend to overlap one another, rather than meet in a clear suture, it is quite possible that the bone in question actually includes a spleniale.

3. Descriptions of the Various Forms

a. AMPHISBAENA FULIGINOSA Linnaeus

Figs. 1, 2, 12 and 18,b

Two skulls of this species were examined and for the purpose of description they will be labeled specimen "A" from South America (no specific locality indicated on the label) and specimen "B" from near Riobamba, Ecuador. Both skulls are of exactly the same size, measuring 14.0 mm. in greatest length and 6.2 mm. in greatest width.[13]

The skull is comparatively long and low. The facial part is but slightly bent downward. The height of the snout just back of the external nares is about the same as in the region of the cranio-facial bend. The snout is blunt and the external nasal apertures are lateral. The cranial cavity is long, slender in front and rather broad and low in the rear.

The occipito-otic region consists ventrally of a wide plate that carries the slightly double knobbed occipital condyle. Laterally it surrounds almost two-thirds of the large foramen ovale, in front it meets the basi-parasphenoid in a symmetrical, posteriorly curved suture medially, and the elements "X" anterolaterally. The canals for the internal carotids are located between the elements "X" and the basisphenoid (Fig. 1-b and 2-b).

The quadrates are relatively long, solid bones. Their longitudinal axes stand to the longitudinal axis of the cranium at an angle of about 30°. The dorsal faces of the quadrates are crested. The basi-parasphenoid is widest in its posterior third where it forms lateral projections very much resembling basipterygoid processes. These wings, however, do not attach themselves to the pterygoids, but are chiefly connected to the anterior margins of the elements "X." Orally the parasphenoid is pointed and its suture with the presphenoid is visible in the region of the pterygo-palatine sutures (Figs. 1 and 12).

The pterygoids are wide in front and rather slender in the back. Anteriorly they extend almost to the posterior tips of the maxillae, separated from these bones only by the irregularly shaped ectopterygoids. Most of the anteromedial edges of the pterygoids face the palatines. The ectopterygoids vary considerably in form and position in different amphisbaenids. In *A. fuliginosa* they appear rather conservatively interlocked between the pterygoids and the maxillae and are laterally located to the palatines. The vomers are long and pointed at both ends. Lateral horizontal leaves connect them with the medial wings of the maxillae and posteriorly with the palatines.

Each maxilla bears 5 teeth, of which the second from the front is the largest; tooth number 4 is the second largest and number 5 is the smallest.

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13 Tip of snout to occipital condyle; greatest width: in the region of the otic capsulae.

Medially the maxillae touch the vomers and medio-posteriorly, for a very short distance, the palatines. The lateral vertical leaves of the maxillae connect with the prefrontals in the back, with the nasals dorsally and with the premaxilla in front, where they help to form the posterior rim of the external nares. A series of presumably nutritive foramina are visible on the lateral faces of the maxillae, situated close to the bases of the conical teeth.

The premaxilla has 7 teeth; the medial one, as always, being the largest. The rest of the teeth are symmetrically distributed over the lateral horizontal wings of this bone, which extend backward only as far as the openings of the Jacobson's organs. The vertical lamella of the premaxilla reaches the roof of the snout, where it appears as a narrow, medial element wedged between the anterior lobes of the nasals. There seems to be some variation in this region. In specimen "B" the nasal elements seem to have overgrown the rostral part of the vertical lamella of the premaxilla, leaving a very tiny, almost round portion of this element surrounded on all sides by the nasals. The latter roof the major part of the snout and meet the frontals in a deeply lobed suture. In this species the surface of the nasal bones is characteristically sculptured. The frontals are about as long as the nasals and are laterally covered by the prefrontals. The parietal is by far the largest plate of the skull. In the medial line there is a faint bony crest that leads to a distinct tuberosity. A little way behind this point the parietal plate is deeply notched. The posterior wings of the parietal overlap the occipito-otic elements to an undetermined extent. The suture between the parietal plate and the frontals is deeply "toothed" like that between frontals and nasals, but the particular design of either suture varies individually.

Each mandible bears seven teeth; their size decreases slightly from front to back. The extent of the various bones of the lower jaw is indicated in Fig. 1. Immediately anterior to the point of articulation there is a rather large hole, piercing mainly the surangular element. In front of this opening there is a somewhat smaller mandibular foramen.

b. AMPHISBAENA EWERBECKI Werner

Figs. 3, 4, 5, 6, 7, and 13

The skull of this form is too small to be normally macerated. A series of cross sections through the head was made and the skeletal elements were subsequently reconstructed by the wax-plate modeling method.[14] The greatest length is 2.75 mm., and the greatest width is 0.95 mm.

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14 A complete series of transversal celloidin sections (35μ) through the head was made and a photomicrograph was taken of each individual section. Prints, properly enlarged, were used as patterns for cutting the wax plates. Instead of using the pieces of wax representing the skull elements, the holes left by them were filled with plaster of Paris. This was not done for each individual section but the model was built up in groups of six plates. After the plaster of Paris had dried, the wax surrounding it was melted away. By this method the difficulty of handling thin and delicate pieces of wax was satisfactorily overcome.

The skull of this species is very long and narrow. The facial part is almost as broad as the widest region of the cranium. The skull is comparatively high, especially in the otic region. There is only a slight bend in the cranio-facial axis. As in *A. fuliginosa* the snout is high, the external nares, however, are

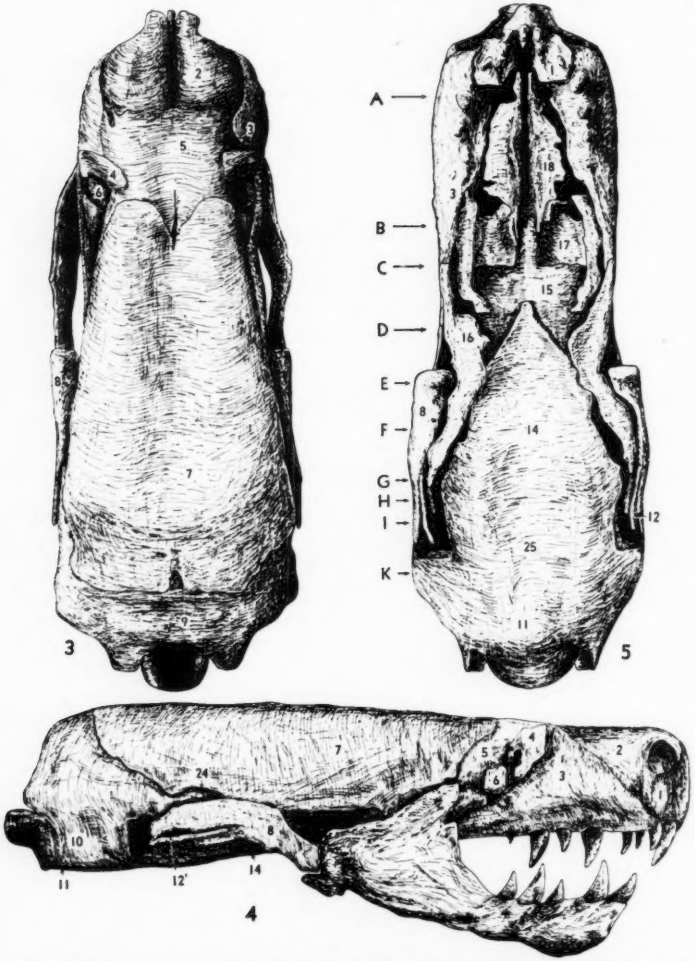

Fig. 3. Dorsal view of the skull of *Amphisbaena ewerbecki*. Drawn from the model illustrated in Fig. 13. Fig. 4. Lateral aspect of the skull of *Amphisbaena ewerbecki*. Fig. 5. Ventral view of the skull of *Amphisbaena ewerbecki*. Arrows refer to cross-section drawings in Fig. 7. About 37 times natural size.

more anteriorly located. The rostrum is moderately pointed. The cranial box is extremely long and voluminous.

The occipito-otic region differs from that of *A. fuliginosa* in a few noticeable points. The ventral plate is fused to the basi-parasphenoid, leaving no trace of a suture. The foramen ovale, characteristically large in other amphisbaenids, is very small and, instead of pointing ventro-laterad, as in other forms, faces the posterior end of the quadrate. A columella auris is absent,

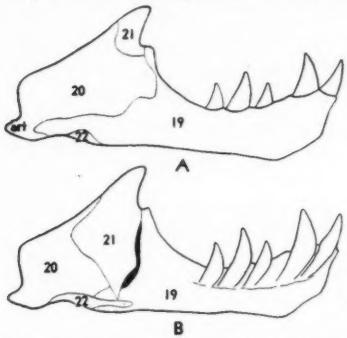

Fig. 6. A, buccal, B, lingual view of the mandible of *Amphisbaena ewerbecki*. The sutures were traced directly from the serial sections. About 37 times natural size.

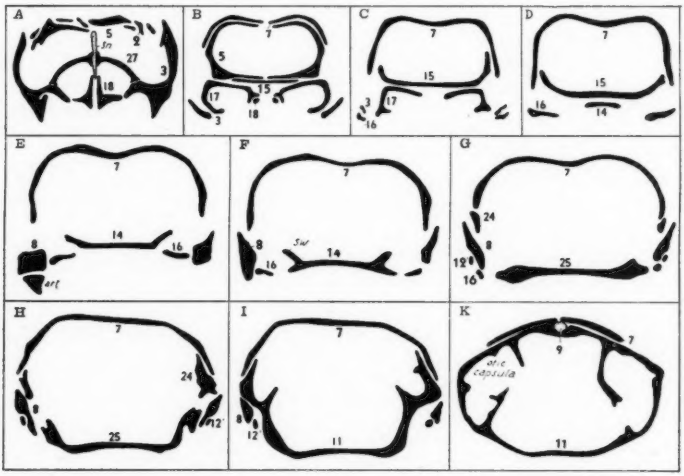

Fig. 7. Cross sections through the skull of *Amphisbaena ewerbecki*. Drawn from photomicrographs. Only bones (black) and some cartilage elements (dotted) are included. The location of the sections is indicated by arrows on Text Fig. 5.

but the extracolumella, bony at the rear and cartilaginous in front, lies in its proper place, the lateral depression of the quadrate. The elements "X" are absent, or perhaps co-ossified with the adjoining bones. The quadrate is long and thin in its posterior portion, which is almost parallel to the axis of the skull. In front it is bent ventrad and inward (Figs. 4 and 5).

The basi-parasphenoid is widest in the region of the posterior ends of the pterygoids; its anterior tip is blunt and underlies, for a short distance, a large medial plate that seems to be homologous to the orbitosphenoid elements in *A. fuliginosa*. A medial element (i.e. the presphenoid) is absent in *A. ewerbecki;* the two lateral plates appear to be fused in the sagittal plane as indicated by an antero-medial notch in the bone.

The pterygoids connect in front directly with the posterior tips of the maxillae, while the ectopterygoids are reduced to tiny flakes lying in the lower parts of the orbital depressions. The dentition of the maxilla is similar to that of the previously described species; the teeth are conical and sharply pointed. The process of tooth reduction has begun at the posterior end; there are only four teeth present, the last is very small. The first and the third tooth are largest. The lateral aspect of the maxilla is triangular; its dorsal end reaches the full height of the snout. The posterior margin of the triangle connects with the prefrontal flake. The vomers are very similar to those of *A. fuliginosa* but their lateral wings do not directly attach themselves to the inner horizontal lamellae of the maxillae.

The premaxilla is deeply notched below, producing two pronounced lateral wings that connect it with the maxillae. As in *A. fuliginosa* there are seven teeth attached to the premaxilla. Each nasal lines its cavity on three sides: dorsally, dorso-medially and dorso-laterally. The medial wall is ventrally continued by the anterior sagittal leaf of the septomaxilla; in front by the vertical lamella of the premaxilla and, dorsal to the capsules for the Jacobson's organ and behind this organ by a cartilaginous nasal septum. The septomaxilla (Fig. 7-A) roofs the organon vomero-nasale, originating ventrally from the medial wing of the maxilla, and dorsally connecting with the basis of the septum nasi. Anterior to the Jacobson's organ it forms an extremely thin, slightly parasagittal leaf.

The frontals are fused anteriorly; in the rear they are separated by a deep cleft. There is a suture between the frontals and nasals, but none between the frontals and the parietal plate. This latter element overlaps the frontals for a short distance. The frontals are somewhat longer than the nasals. The parietal plate is extraordinarily large; instead of a medial crest, there is a shallow longitudinal depression. Each mandible (Fig. 6) carries but five teeth; the second from the front is the largest, next to it in size are the fourth and the first.

c. AMPHISBAENA CUBANA Peters

Fig. 8

The skull described below belongs to a juvenile individual. Its greatest length is 6.8 mm., and the greatest width is 3.0 mm.

The general topography of the skull of this species very much resembles that of *A. fuliginosa*. The chief difference lies in the shape of the snout. It is pointed and rather low at its tip. The external nasal openings are lateral. The facial portion of the skull is much narrower and somewhat smaller than in *A. fuliginosa*, while the cranio-facial angle is about the same. The otic capsules, with enormous semi-circular canals, are very large.

The ventral part of the occipito-otic region is relatively longer than in *A. fuliginosa* and the basi-parasphenoid is smaller than in that form. The elements "X" are large and mostly border the basi-parasphenoid. The suture between the basioccipital region and the basi-parasphenoid is "V"-shaped.

The pleurosphenoid region is slightly different from the usual condition. The anterior process, which usually accompanies the lower edge of the parietal (Fig. 1), points dorsad (Fig. 8; no. 24). The quadrate is shorter than in *A. fuliginosa* and its dorsal face is highly crested. A rather large foramen is visible on the outer surface of the bone near its proximal end. The pterygoid is widest at mid-length, at the point where it touches both the palatine and the basi-parasphenoid. In front of this point it extends along the outer margin of the palatine and its front end meets the ectopterygoid in a curved suture. The palatines are much larger than in *A. fuliginosa*. They wedge themselves between the pterygoids and the major part of the tip of the parasphenoid. In front of this bone the palatines join medially, thus separating the anterior end of the parasphenoid from the posterior ends of the vomers. These latter elements are relatively short and reach the anterior border of the openings of the Jacobson's organs (Fig. 8).

There are five teeth on the maxilla. The middle one is the strongest, and numbers one, two and three from the front are of about equal length. Otherwise the maxilla resembles very much that of *A. fuliginosa*. The premaxilla bears seven teeth; of the lateral teeth, the third is about half as long as the medial one. The dorsal longitudinal lamella is very well developed. On the roof of the snout it separates not only the nasals, but also the anterior portion of the frontals.

The frontals and nasals are of about the same length and the suture between them is simple. The suture between the frontal plates and the parietal, however, is deeply lobed. The extent of the frontals in the region of the orbital depressions could not be exactly made out (Fig. 8; no. 5). The parietal is smooth and does not overlap the occipito-otic complex as far as it does in the other species of this genus. Along the postero-lateral edges of the parietal the anterior semi-circular canals are plainly visible from the outside.

The mandible resembles very much that of *A. fuliginosa*. It bears seven teeth, but the sutures between the various elements could not be distinguished with certainty.

d. BIPES BIPORUS Cope
(Chirotes)
Fig. 9

As the name *Bipes* suggests, this form has a well developed set of anterior extremities, of which hardly any vestiges remain in any of the other amphis-

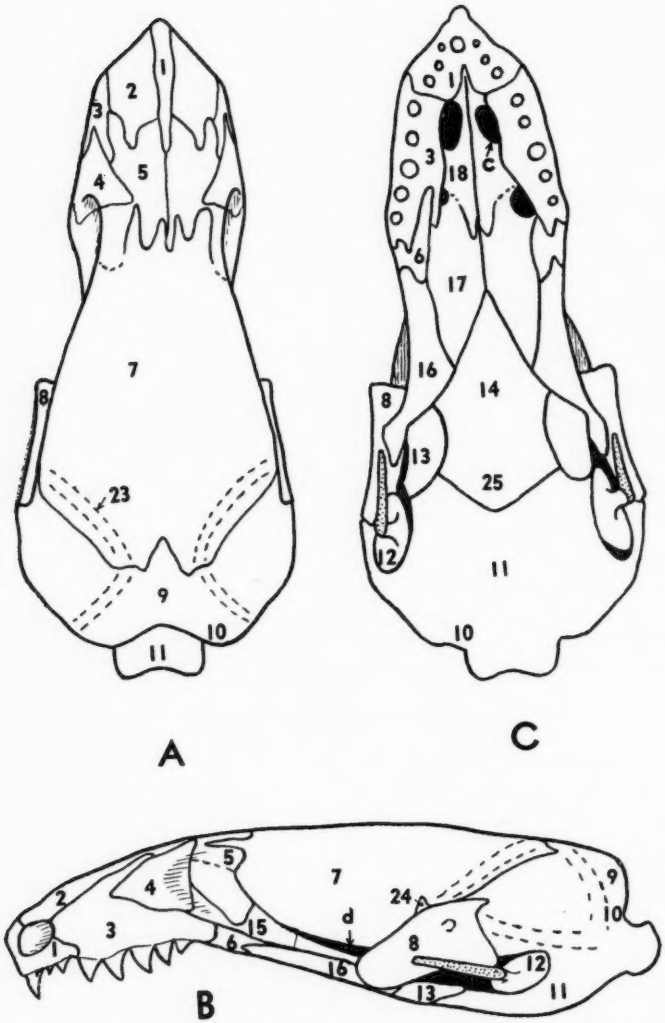

Fig. 8. Skull of *Amphisbaena cubana*. The dotted elements in figures B and C represent the cartilaginous extracolumellae. The dashed lines in the otic region mark the position of the semi-circular canals. About 15 times natural size.

baenids. It was suspected that *Bipes* might be a much more primitive form also as far as the skull is concerned; but in general shape as well as in construction the skull of *Bipes* closely follows the line observed in all the other representatives of the family studied. The measurements are: greatest length, 6.2 mm.; greatest width, 3.7 mm.

The *Bipes* skull could be characterized as of the *Amphisbaena*-type, but it is much stouter than in any of the species of that genus in which the skull has been described. The facial region is rather short and wide. Its anterior

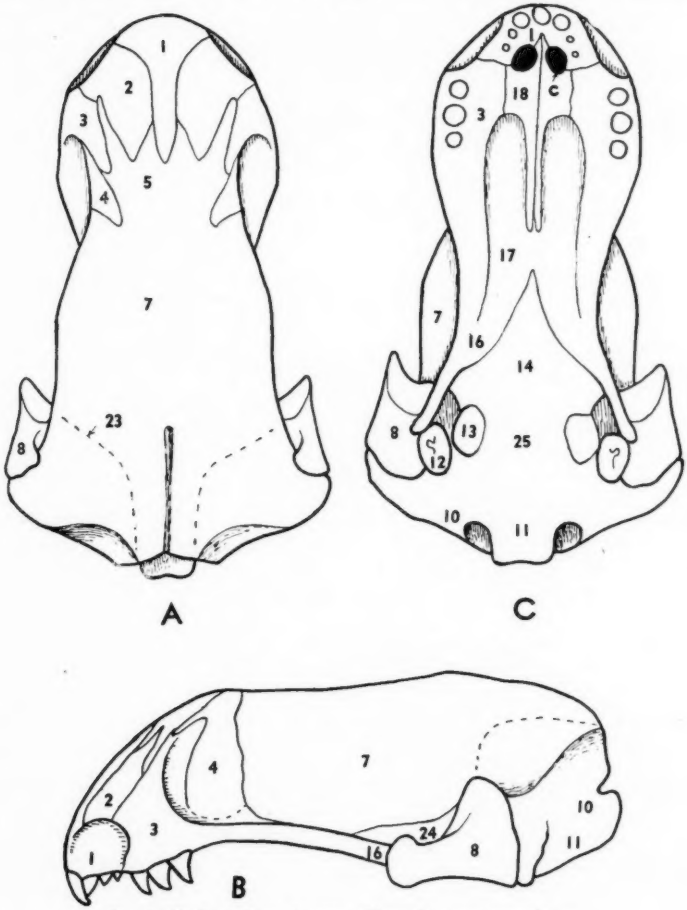

Fig. 9. Skull of *Bipes biporus*. About 14 times natural size.

margin is rounded, as in *A. fuliginosa,* and the premaxilla does not protrude beyond the medial tooth.[15] The external nasal openings are lateral. The cranio-facial angle is not very great, but the roof of the snout declines steeply toward the front (Fig. 9). The cranial cavity is extremely voluminous, being both high and wide. The occipito-otic region bears, as in the skull of *Amphisbaena* a small occipital condyle. The lateral knobs to which the quadrates are attached are very large in *Bipes,* while the foramina ovalia with their stapedial foot plates are comparatively small. The elements "X" are present, but no suture between the basioccipital-basisphenoid regions could be noticed.

The quadrates are very stout; they have extensive articular surfaces for the lower jaws and proximally they are firmly attached to the lateral wings of the otic region by means of large joint surfaces. The postero-dorsal crista of the quadrate, noteworthy in *A. fuliginosa,* is still higher in *Bipes.* The exact extent of the roof plates of the mouth cavity is not clear, with the exception of the vomers, which form lateral bridges in front to connect with the maxillae, thus separating the choanae from the openings leading to the Jacobson's organs. Posteriorly the vomers carry long and slender processes that do not touch the oral tip of the parasphenoid.

The maxillary dentition is reduced to three teeth as in *Geocalamus,* but in *Bipes* they are stronger and of about the same size. In shape the maxilla, with its high dorsal projection (Fig. 9) resembles that of *Amphisbaena.* There are seven premaxillary teeth as in the various species of *Amphisbaena* where that number seems to be rather constant. Of the three lateral teeth, on each side, the first is by far the largest in *Bipes.*

The bony pattern of the roof of the snout compares well with that of *A. cubana,* except that the premaxilla is much wider, particularly in front and that there is no suture between frontals and parietals; all four plates are solidly fused (Fig. 9). The posterior margin of the parietal plate overlaps the entire supraoccipital and edges onto the foramen magnum. Instead of the usual notch, the parietal carries a fairly strong crista, that begins abruptly with a tuberosity and ends at the edge of the foramen magnum. Its length amounts to about ¼ of the length of the skull.

The lower jaw somewhat resembles that of *Geocalamus;* it also bears six teeth, but the coronoid process is shaped more as in *A. fuliginosa.* The crowns of the teeth are rather stout.

e. GEOCALAMUS ACUTUS Sternfeld

Figs. 10, 11, A and B, and 18,c

The skull of *Geocalamus* much resembles that of *Amphisbaena,* though it represents a more advanced type. The skull examined is 6.6 mm. long and has a greatest width of 2.7 mm.

Compared with that of *Amphisbaena cubana,* the snout of *Geocalamus* is narrower and more pointed, the rostrum protruding beyond the medial premaxillary tooth. The cranio-facial angle is much more pronounced and the

15 See *Geocalamus, Rhineura* and *Monopeltis* below.

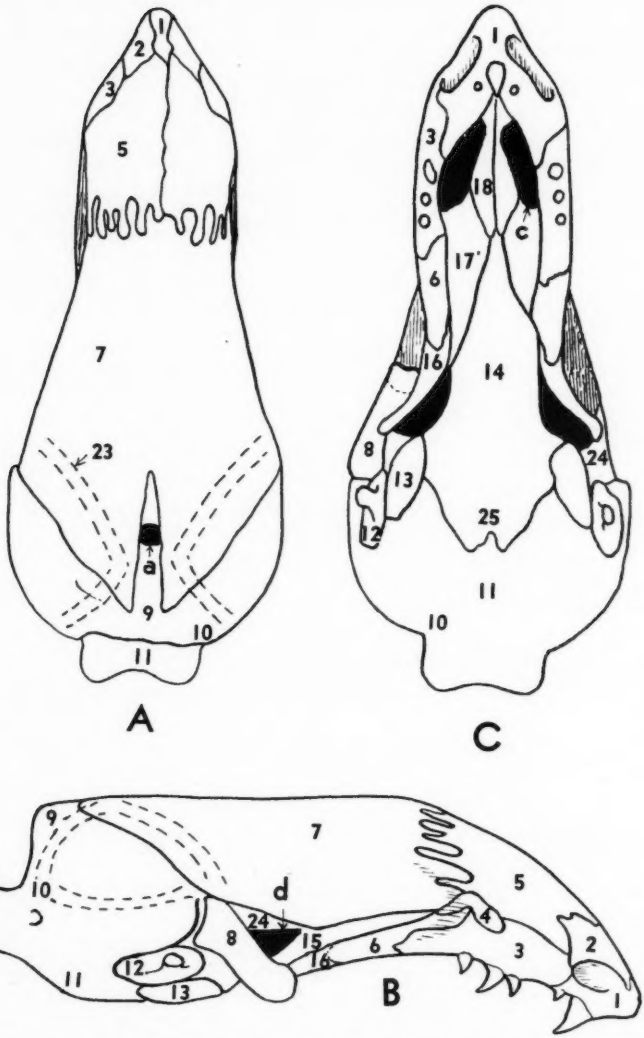

Fig. 10. Skull of *Geocalamus acutus*. The dashed lines in the otic region indicate the position of the semi-circular canals. About 15 times natural size.

dentition has been somewhat reduced. The snout is low in front, but in the region of the angulation the skull is almost as high as in the otic region. The orbital depressions are very shallow.

The occipito-otic region is even larger than in *A. cubana*. The ventral bulge of the basioccipital plate is at least as marked as in that species. The occipital condyle is much larger, particularly wider, than in any species of the genus *Amphisbaena* herein described. On either side of the condyle there is a foramen probably serving as outlet for the vagus and hypoglossus nerves. The suture between the ventral occipital plate and the basi-parasphenoid is W-shaped, and the elements "X" are well developed. The basi-parasphenoid is long and shaped like an arrowhead; its tip reaches almost to the anterior end of the palatines. As in *A. fuliginosa*, but more pronounced in *Geocalamus*, there is a fenestra between the lateral edge of the basi-parasphenoid and the pterygoid.

The quadrate is rather short; the angle between its axis and that of the cranium amounts to about 40°. The pterygoids are unusually short, extending only a little way beyond the front ends of the quadrates, where they attach themselves medially to the palatines and orally to the elongated ectopterygoids. In *Geocalamus* the major part of the palatine lies behind the tip of the parasphenoid and its anterior edge rims the large fenestra which represents the internal nasal opening plus the inlet to the Jacobson's organ. This is not a major difference from the condition in *Amphisbaena*, since the separation of the two openings is usually accomplished by lateral bridge-like wings of the vomers, which fuse with the inner margins of the maxillae. In *Geocalamus* these lateral processes of the vomers are faintly perceptible.

The maxillae are very much reduced; they are short and weak and carry but three teeth each, of which the middle one is largest, the other two being of about equal size. The dorso-lateral wall of this element is low. The size relationship of the bones of the snout is very different from that in *Amphisbaena*. The largest plates are the frontals, which almost cover the entire facial region, leaving little territory for the nasals and the premaxilla, which occupy only the rostral part of the skull. The premaxilla is not small, since its ventral development is considerable. It bears only three teeth, the two lateral ones being very small, while the medial is the largest tooth of the entire dentition. The dorsal pillar of the premaxilla is narrow and short, but its posterior end touches the frontals. The nasal elements are tiny flakes on either side of the vertical lamella of the premaxilla.

The prefrontals are small elements, lying at either side of the fronto-parietal suture, which is deeply curved. The parietal plate is larger than in *A cubana*, but equally smooth. A very deep notch separates the parietals posteriorly and the hole, originally filled by the cartilaginous part of the medial prong of the supraoccipital, is well exposed. Also in this form the semicircular canals can be seen from the outside (Fig. 10).

Each ramus of the lower jaw has six teeth (Fig. 11) the tips of which point backward. The coronoid process is unusually low.

f. TROGONOPHIS WIEGMANNI Kaup

Figs. 14 and 18,a

As far as the adaptive features are concerned, the skull of *Trogonophis* occupies a separate place among the amphisbaenids studied. Its measurements are: greatest length 13.2 mm.; greatest width 6.0 mm.

The facial region is comparatively large and distinct from the cranial part. Its walls converge rostrad to end in a blunt tip. The external nares are lateral and the dentition is remarkably modified. The brain case is very slender, especially in front. The axial angulation equals or slightly surpasses that of *Geocalamus*.

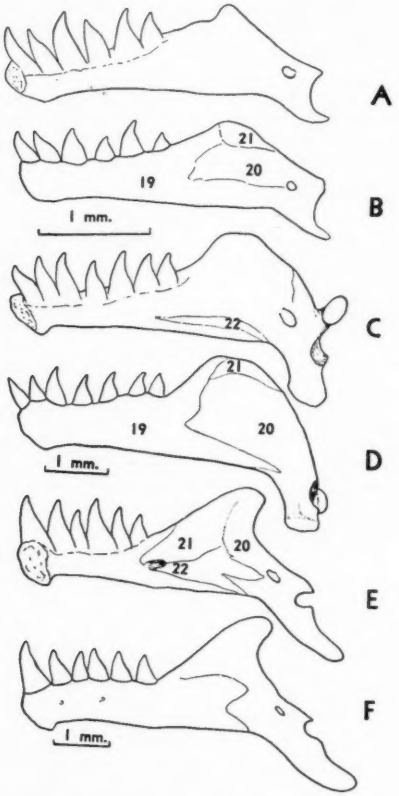

Fig. 11. Outline drawings of the mandibles of A and B *Geocalamus acutus;* C and D *Monopeltis c. capensis;* E and F *Rhineura floridana.* B, D and F, buccal views; A, C and E, lingual views. It is extremely difficult to locate sutures. Only those lines clearly recognized as sutures are included in the drawings.

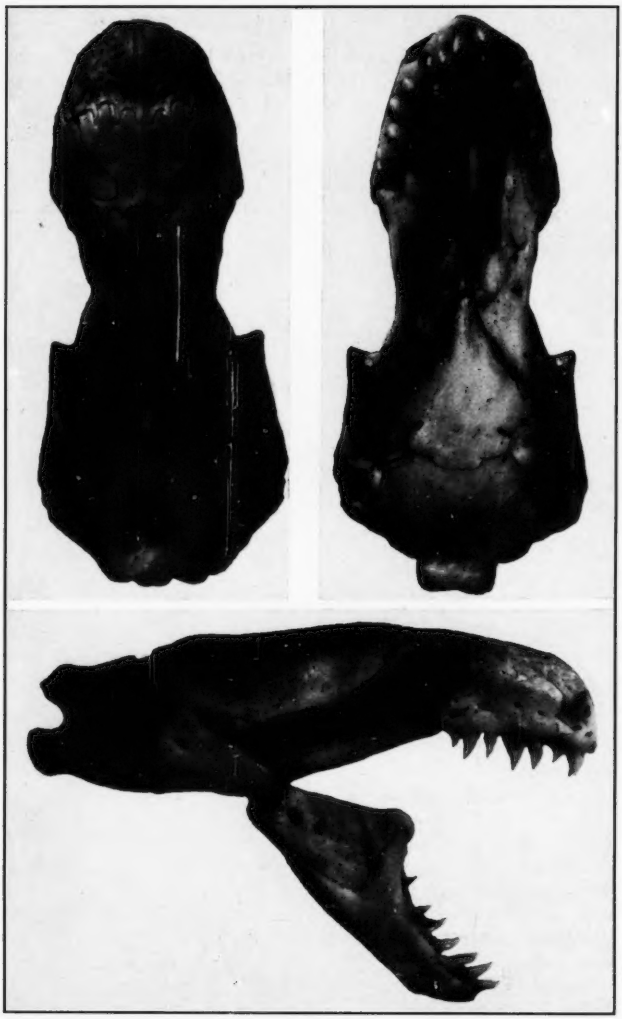

Fig. 12. Photograph of the skull of *Amphisbaena fuliginosa* (spec. "A"). Compare with Fig. 1. About 6 times natural size.

The occipito-otic region is relatively short, but rather wide; its ventral plate forms a small occipital condyle and meets the basi-parasphenoid in an almost straight suture. The elements "X" are small, but distinct. On the lateral surface of the otic region, just behind the aboral end of the quadrate, there is a tiny flake that is absent in all previously described species. Von Bedriaga (loc. cit.) found an equally small element in *Blanus cinereus* and labeled it the squamosal. This interpretation is good, since the position compares favorably with the location of the squamosal in snakes. In *Monopeltis* and particularly in *Rhineura* (see below) this bone is much better developed. The anterior process of the pleurosphenoid is large and makes up a considerable part of the side wall of the cranial cavity. The basi-parasphenoid is rather slender; close to its posterior end it forms lateral processes that fasten the elements "X" in front, but they fail to touch the pterygoids. Just in front of these processes the basi-parasphenoid becomes very narrow and remains so almost to its tip, which reaches the aboral ends of the vomers a little anterior to the pterygo-palatine suture. The dorsal longitudinal side walls of the basi-parasphenoid (Figs. 2 and 7, as shown for *A. fuliginosa* and *A. ewerbecki*) are much higher than in the other form, thus providing a channel for the reception of the ventral portion of the brain. The skull of *Trogonophis* was not dissected for the examination of the presphenoidal and orbitosphenoidal regions. From what can be seen on the ventral side of the cranium there seems to be a parasphenoid-presphenoid suture and the presence of a set of orbitosphenoid plates is certain.

The quadrate is moderately long, but highly crested in its upper part and the joint surface for the adaptation of the lower jaw is wide and extends well backward on the ventral face of the element. A foramen is visible on the lateral side of the dorsal crest. The pterygoid is long and slender except at its front end where it is connected mostly to the palatine and by only one lateral prong to the ectopterygoid (Fig. 14). There is nothing unusual about the palatines, but the vomers have very long and thin posterior processes, which separate the palatines. A bridge between vomer and maxilla is present, but it is narrow and it forms the posterior rim of the opening leading to the Jacobson's organ.

The shape of the maxilla is unique; its rear end is elongated in the form of a massive postero-lateral process, which is distally somewhat enlarged.

The dentition is acrodont; in the maxilla it consists of four teeth, the second from the front is by far the largest. Numbers three and four are small and about equal in size. The shape of the maxillary teeth differs considerably from that of the teeth in all the other species studied. The bases of the teeth are longer than wide and touch one another. All the teeth are pointed and the second tooth is posteriorly crested (Fig. 14). Two large foramina are present on the lateral face of the maxilla just beyond the middle teeth. The ectopterygoid fills the triangular cleft between the outwardly turned rear end of the maxilla, the palatine and the pterygoid.

In *Trogonophis* the dorsal development of the premaxilla surpasses its ventral portion. It actually roofs the major part of the snout and in the back

meets a rostrally directed medial process of the parietal plate (Fig. 14). The lingual surface of the premaxilla carries five teeth, the medial one being conical and long and the tip of its crown faces the back of the mouth. The lateral teeth are small, but shaped like those of the maxilla. Lying in the anterior corner of the external nasal opening there is a small distinctly outlined bone

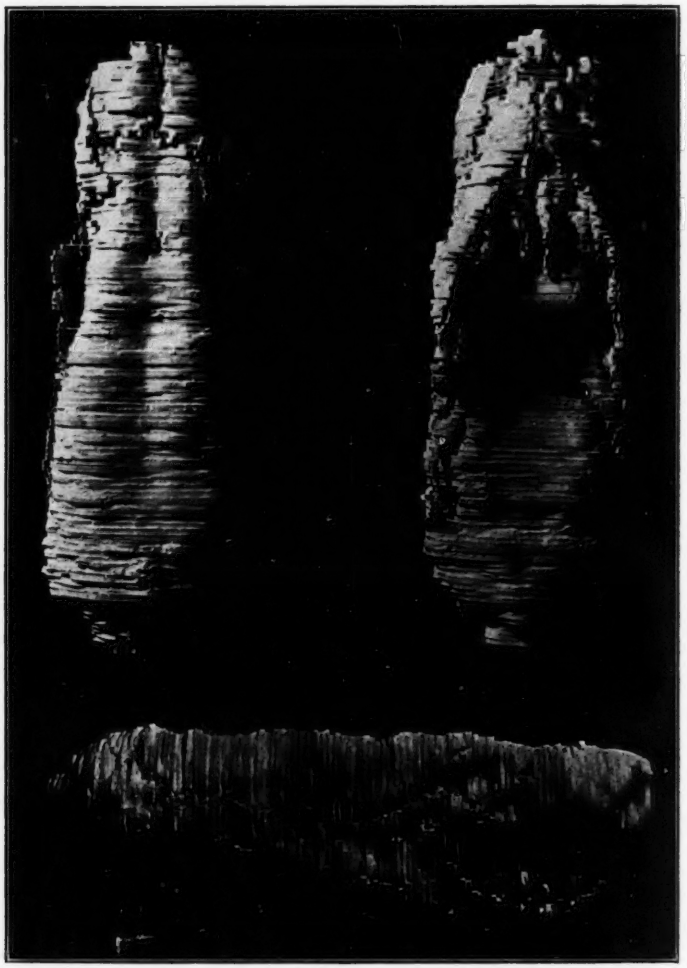

Fig. 13. Photograph of the skull model of *Amphisbaena ewerbecki*. Compare with Figs. 3, 4, 5 and 6. About 34 times natural size.

that can be clearly seen on both sides of the specimen (Fig. 14). The inner extent of this element could not be worked out since some remains of the nasal epithelium that could not be safely removed obstructed observation. It is probably reasonable to assume that these externally visible elements represent greatly enlarged anterior processes of the septomaxillae (see description of this element in *Amphisbaena ewerbecki*).

The nasals are small bones on either side of the dorsal premaxillary plate. They join the relatively small frontals in a clear-cut, deep suture (Fig. 14). *Trogonophis* is the only form in which the frontals are dorsally separated by an anterior process of the parietal. The lobes of the fronto-parietal suture are extremely deep. Laterally each frontal is divided into two portions by a narrow, anterior process of the parietal element which reaches so far forward that it touches a sutural "tooth" of the maxilla (Fig. 14). The prefrontal is small and forms most of the anterior wall of the orbital depression.

The parietal plate is dorsally crested and an oblong tuberosity is developed at about mid-length of the skull. In the rear the parietal does not overlap the otic region as much as in the other forms, but it covers most of the supraoccipital. The typical notch separating the caudal part of the parietal element is deep and slender.

The lower jaw of this form is relatively large (Fig. 18, a). Its general shape recalls that of a mammalian mandible. The teeth look very much like those of the upper jaw and there are eight on each side. The first four are nearly twice the size of the rear ones. The dentary seems to make up most of the lateral face of the ramus, while the rest of the elements are mostly visible on the lingual side. The angular appears to be very much larger than in the other forms.

g. RHINEURA FLORIDANA Baird

Figs. 11, E and F, and 15

The adaptive features exhibited in the skull of this form and of *Monopeltis* (see below) clearly bear the stamp of burrowing life. The entire facial region is shaped like a shovel. The skull of *Rhineura* available for examination measures 10.2 mm. in greatest length and 4.8 mm. in greatest width.

The anterior part of the skull is wide, dorsally almost flat and its front edge is sharp. The external nasal apertures are on the ventral side of the shovel-shaped snout. The rostral part of the snout lies in front of the median premaxillary tooth. The cranio-facial angle is greater than in any of the previously described forms. The brain enclosure is as wide anteriorly as it is in the region of the otic capsules. The foramen magnum is very large and the occipital condyle is distinctly double knobbed and very wide (Fig. 15).

The ventral plate of the occipito-otic region is relatively short and fused to the basiphenoid element. A very minute line, connecting the medial tips of the elements "X," is well visible on Fig. 15; it possibly takes the place of the original suture. The foramen ovale is large and the stapes is massive. The lateral knobs, which serve as attachment places for the quadrates, are covered

by the rather large squamosals (Fig. 15), which dorsally make contact with the parietal plate.

The anterior rim of the foramen ovale is pierced by a small foramen that lies in such a position as to be interpreted as a facial foramen. The pleurosphenoid borders this opening in front with a vertical pillar; dorsally it forms

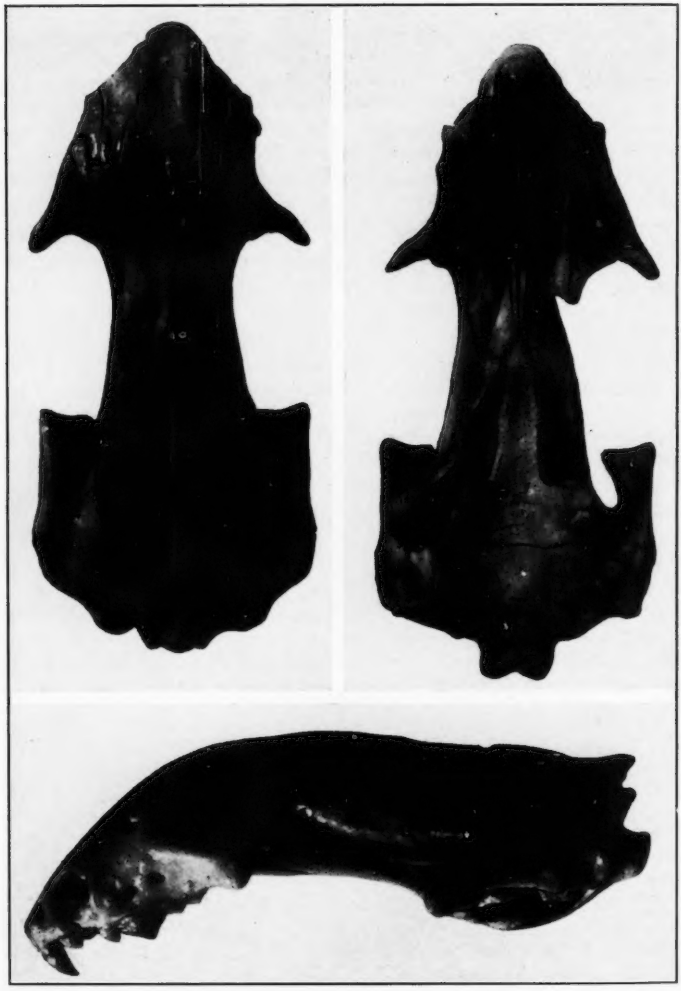

Fig. 14. Photograph of the skull of *Trogonophis wiegmanni*. About 7 times natural size.

a large part of the side wall of the brain case and connects anteriorly with the large orbitosphenoid wings (Fig. 15). The basisphenoid resembles that of *Trogonophis* but is larger in *Rhineura*. The anterior faces of the "basipterygoid processes" are firmly attached to the pterygoids, which also frame the lateral edges of the anterior portion of the basisphenoid. The front end of this bone separates the posterior processes of the vomers. The skull was not dissected, but the foramen magnum is so large that some observations on the interior of the brain cavity could be made. In front of the basi-parasphenoid there appears to be a presphenoid which forms a slight ridge on the floor of the brain case. Sutures surrounding the element, however, could not be seen.

The quadrate is very short and stands at an angle of nearly 80° to the longitudinal axis of the cranial portion of the skull. As in most forms there is a foramen on the lateral surface of the quadrate just at the basis of the dorsal crest. The shape of the pterygoid is characteristic. Its main body lies directly in front of the "basipterygoid process." Posteriorly it sends to the ventro-medial surface of the quadrate a stout process, which is typical in all forms. In front there are two processes, the medial one accompanying the outer margin of the blade of the spearhead-shaped basi-parasphenoid and touching the aboral tips of the vomers, the lateral process attaching to the outer surface of the elongated ectopterygoid. The area between the two pterygoidal processes is taken up mostly by the palatine and to a minor degree by the ectopterygoid. The vomers are relatively sturdy bones, but their lateral wings are small, forming merely the posterior rims of the openings to the Jacobson's organs.

The maxilla is a strong bone that carries four conical teeth. The second from the front is the largest, next to it in size is the first tooth, and the fourth is the smallest. The lateral face of the maxilla shows a number of irregular impressions that lead to presumably nutritive foramina. On the ventral side the maxilla bears a posterior prong wedged between the palatine and the ectopterygoid (Fig. 15). An anterior process of the maxilla forms the posterior and medial rim of the external nasal opening. The premaxilla is small; it has but one medial tooth. The wings that in other amphisbaenids carry the lateral premaxillary teeth, are very short in this form and do not border the openings leading to the Jacobson's organs. The dorsal extension of the premaxilla is limited to the very tip of the rostrum where it is much wider than long.

The nasal and frontal plates roof the major part of the facial region of the skull. Both pairs of bones join medially in a somewhat irregular suture. The nasals are about $\frac{2}{3}$ as long as the frontals. The surface of the latter elements is rather rough, but not sculptured as are the nasal bones of *A. fuliginosa*. The postero-lateral edges of the frontals form a slight ridge that marks the rear end of the shovel-shaped facial region. The prefrontal is large, shaped as shown in Fig. 15. The parietal plate is about of equal width in front and behind. The frontal ridges described above are continued by the parietal to complete the letter "V," analogous to the V-shaped frontal crest of the canine skull. Posteriorly the parietal overlaps most of the occipito-otic region and its medial notch is not very deep.

The lower jaw (Fig. 11, E and F) bears six teeth, the first being the

largest. The sizes of the other teeth vary somewhat and corresponding teeth of the two mandibles may be different in size. The coronoid and retroarticular processes are pronounced. The articular surface is located below the level of the symphysis.

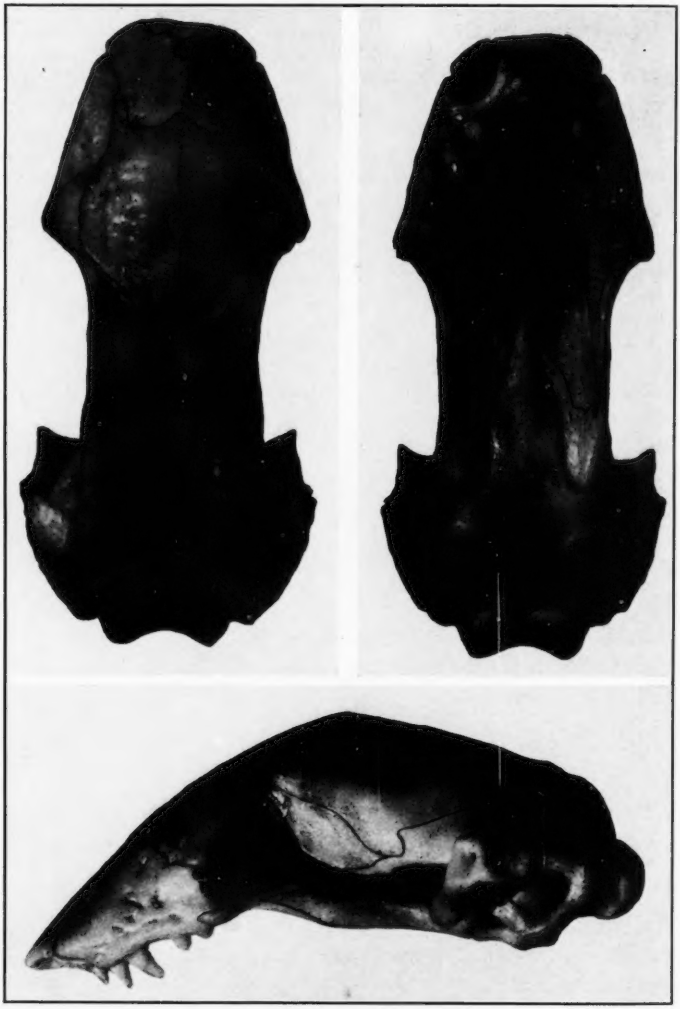

Fig. 15. Photograph of the skull of *Rhineura floridana*. About 9 times natural size.

h. MONOPELTIS C. CAPENSIS Smith

Figs. 11, C and D, and 16

The skull of *Monopeltis* is further specialized along the same general lines as that of *Rhineura*. The skull available is 10.0 mm. in greatest length, and 5.7 mm. in greatest width.

The skull is stout. Its facial shield is wide, the lateral edges protruding considerably beyond the maxillary tooth line. The cranial part is short and broad in the region of the otic capsules, which are enormous. The approximate outlines of the otic capsules are shown in Fig. 16. The foramen magnum is at least twice the size of that in *Rhineura* and so is the occipital condyle (Fig. 16). There is a distinctive suture between the ventral plate of the occipito-otic complex of bones and the basi-parasphenoid. The suture lies mostly in front of the elements "X." During the maceration of the specimen the right quadrate and the posterior part of the adjoining pterygoid broke off. Underneath the pterygoid where it joins the "basipterygoid process" and close to the anterior rim of the foramen ovale there appears to be another little bone flake for which there is, as in the case of the element "X," no homologon in the reptilian brain case. Even more than the element "X," this second ossicle recalls an amphibian operculum.[16]

The foramen ovale is much larger than in any of the other studied forms. It is closed by a massive stapes, the column of which is short and very stout. The extracolumella (removed in the specimen shown in Fig. 16) is as wide as the distal tip of the stapedial knob.[17] The basi-parasphenoid is relatively wider than in *Rhineura*. It forms distinct "basipterygoid processes," whose topographic relationship to the pterygoids is the same as in *Rhineura*. The front end of the basi-parasphenoid separates the posterior ends of the vomers but slightly.

The quadrate is of about the same length as in *Rhineura*. Its axis stands at an angle of about 85° to that of the brain case. The proximal end is the largest. It carries a rather high dorsal crest, and the distal articular surface is not enlarged as in *Rhineura*. A squamosal is present (Fig. 16). It is smaller than in *Rhineura*, but larger than in *Trogonophis* and, according to von Bedriaga (loc. cit.), in *Blanus cinereus*. The shape of the pterygoid is almost the same as in *Rhineura* except that the medial anterior process does not touch the aboral end of the vomer, the palatine making that connection.

An interesting difference from *Rhineura* is seen in the location of the ectopterygoid. In *Rhineura* the latero-anterior prong of the pterygoid is attached medially to the ectopterygoid, which in turn is medially connected to an aboral process of the maxilla (Fig. 15). In *Monopeltis* the ectopterygoid lies medial to the posterior maxillary process and does not touch the outer prong of the pterygoid. It furthermore joins the unusually elongated posterior wing of the premaxilla (Fig. 16) and the lateral bridge of the vomer, which cannot

16 In some amphibians there are two opercular cartilages.

17 A small opening, interpreted as facial foramen in *Rhineura* is also well visible in *Monopeltis*.

reach the maxilla. The positional difference of the ectopterygoid in *Rhineura* and *Monopeltis* is probably of little morphological significance, since this element has at least two anterior projections in *Amphisbaena fuliginosa,* one lateral and the other medial to the posterior process of the maxilla. In *Rhineura* the medial portion of the ectopterygoid is probably reduced, in *Monopeltis* it is the lateral portion that has undergone reduction.

The maxillary dentition consists of two teeth, the posterior being the longer. The ventral aspect of the maxilla roughly corresponds to that in *Rhineura* (Figs. -5 and 16). The premaxillary dentition, as in *Rhineura,* is

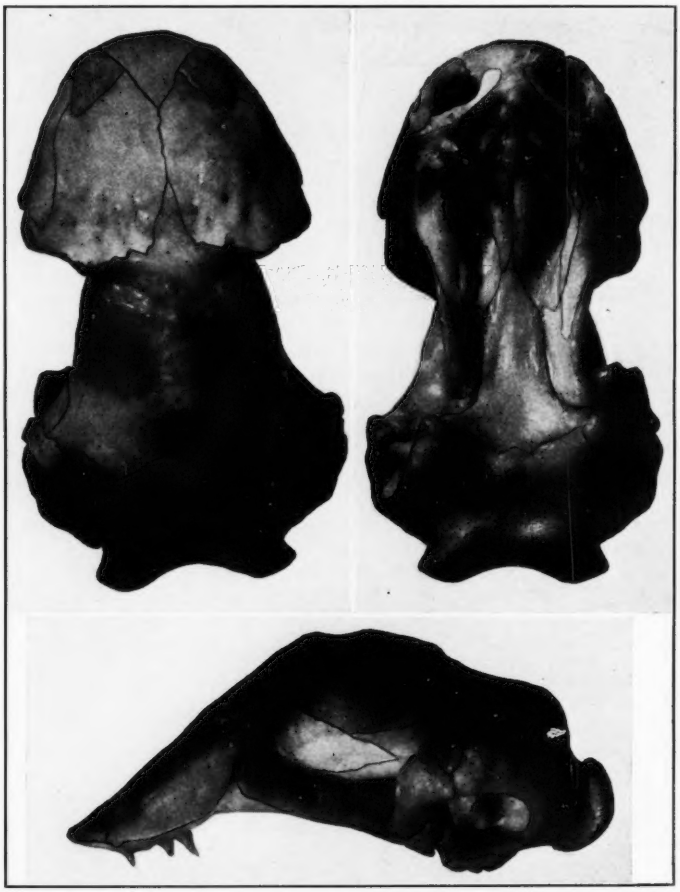

Fig. 16. Photograph of the skull of *Monopeltis c. capensis.* About 8½ times natural size.

reduced to the medial tooth, but the bone itself is very much larger than in *Rhineura*. As mentioned above, the ventral wings of the premaxilla reach very far back in *Monopeltis*, almost to the anterior rim of the choanae. The dorsal extension of the premaxilla makes up a considerable triangular part of the facial shield separating the nasal plates widely. The frontals are much larger than the nasals and form the major part of the facial "digging shovel." The parietal plate is short and wide. In front there is a wedge-shaped process that partly separates the frontals. In the rear there is the typical parietal notch, in which the anterior prong of the supraoccipital is located. In *Monopeltis* this process is large and removal of its unossified part during maceration leaves a big hole in the roof of the skull (Fig. 16).

The lower jaw is unique in shape (Fig. 11, C and D). Dorsal to the articular surface there is a strong medial process, the distal end of which is slightly enlarged and smooth.[18] The ventral projection bearing the articular surface and the retroarticular process is turned outward. The dentition consists of seven almost uniform teeth. It is noteworthy that the extreme tooth reduction of the upper jaw did not affect the dentition of the mandible.

i. LEPOSTERNON MICROCEPHALUM Spix.

Fig. 17

The skull of *Leposternon* generally resembles that of *Monopeltis*, the rostral portion of the facial shield, however, is more pointed than in *Monopeltis*. The skulls examined are (C.M. No. 9025) 18.6 mm. long and 10.9 mm. broad in the otic region and (C.M. No. 9021, juvenile specimen) 10.2 mm. long and 5.7 mm. wide.

As in *Monopeltis* the facial shield is shovel-shaped and separated from the cranial portion of the skull by a distinct transversal crest that is more pronounced in the larger specimen. The dorsal surface of the facial shield is somewhat concave. The cranio-facial angle amounts to about 130° as in *Monopeltis*. The external nasal openings are ventral as in *Geocalamus*, *Rhineura* and *Monopeltis*, but much closer together than in any of these forms.

In the juvenile specimen several sutures in the occipito-otic region are still visible. The basioccipital forms the medial part of the occipital condyle. Its anterior border is deeply concave; laterally it reaches forward to the openings for the internal carotids and borders the elements "X" medially. In the smaller specimen the elements "X" were for the greater part still cartilaginous and only the already ossified portions were preserved during maceration. Thus the suture between the exoccipital-opisthotic and the proötic (normally covered by the elements "X") became visible on the ventral aspect of the skull (Fig. 17).

The basisphenoid is not fused to the parasphenoid in this specimen. The suture lies at the level of the foramina for the internal carotids, and is also visible in the larger skull.

18 Future dissection of fresh material will have to give the answer as to the probable function of this strange projection.

The parasphenoid is a large, approximately triangular plate. The two posterior corners of the triangle make contact with the pterygoids, thus representing the physiological equivalents of basipterygoid processes. The amphisbaenids appear to have this condition in common with certain caudata (e.g. with *Ambystoma punctatum*). A separate presphenoid is absent in *Leposternon*.

The suture between exoccipital and opisthotic has already disappeared in

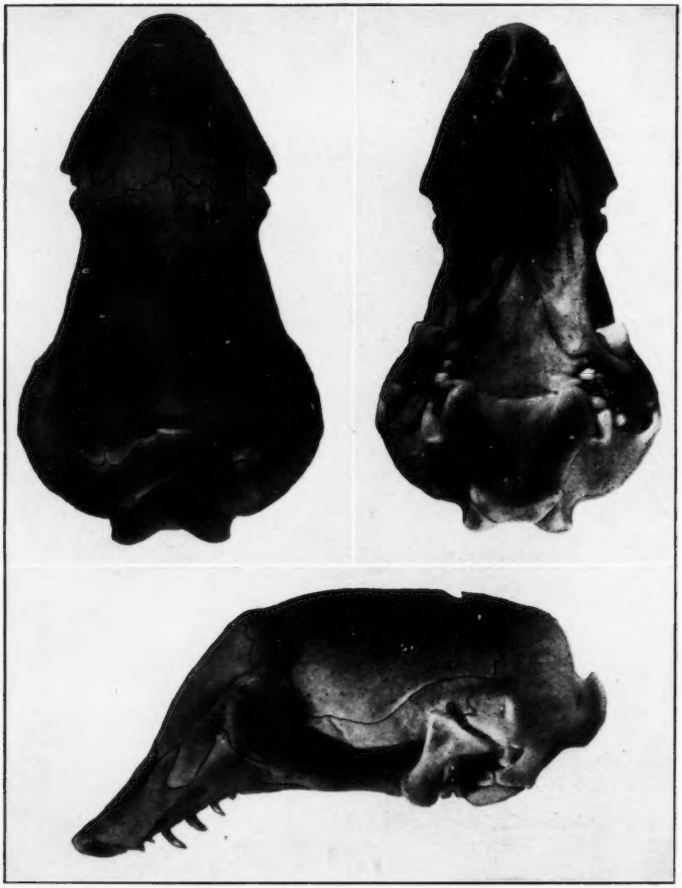

Fig. 17. Photograph of the skull of *Leposternon microcephalum*. About 8 times natural size.

the smaller specimen; there is, however, a clearly visible suture in the proötic region. It separates von Bedriaga's paroccipital process (loc. cit.) from the proötic element, thus confirming the writer's previous opinion, that this region consists of an anterior pleurosphenoid fused to the proötic in the adult condition. The orbitosphenoids form a trough in front of the pleurosphenoids in much the same fashion as was observed in the other forms.

The foramen ovale of *Leposternon* is slightly smaller than that of *Monopeltis,* the stapes resembles that of *Rhineura.*

The construction of the roof of the mouth cavity is identical in every detail with that of *Monopeltis,* the difference in appearance is caused by a difference in width of the various bones and their processes. These are very broad in *Monopeltis* whereas in *Leposternon,* with its more narrow and pointed facial shield, the bones of the roof of the mouth cavity are more slender and delicate.

The dentition of the maxilla consists of four teeth as in *Rhineura,* the first one, however, is the largest. In *Rhineura* and *Monopeltis* the maxilla forms an antero-medial process which borders the external nasal apertures posteriorly and medially. Such a process is not present in *Leposternon.* Instead the maxilla forms the posterior and lateral edge of the nasal opening as in *Amphisbaena, Geocalamus* and *Trogonophis.*

The shape of the premaxilla is unique. Its main portion lies between and in front of the nasal openings. Two slender processes extend caudad to meet, as in *Monopeltis,* the anterior tip of the ectopterygoids. The sagittal leaf of the premaxilla which reaches the surface of the facial shield is of average length. Its dorsal edge, immediately behind the rostral tip, is narrow, further back it carries lateral, horizontal wings thus assuming oval shape; still further back, wedged between the frontals, it is narrow again.

The nasals do not reach the edge of the facial shield; *Leposternon* differs in this character from all forms studies. The frontals form the major part of the facial shield. Their suture with the parietal plate runs approximately parallel with a distinct transversal crest that marks the dividing line between the cranial and facial portions of the skull. The prefrontals are large and resemble those of *Amphisbaena fuliginosa* rather than those of *Monopeltis* or *Rhineura.*

The parietals seem to co-ossify early in life. It is possible that the squamosal flakes have fused with the parietal plate. An indication of this is seen in the younger specimen (Fig. 17) where the most posterior tips of the parietal bone are longitudinally divided.

The mandible resembles most closely that of *Monopeltis* (Fig. 11, c, d); each ramus bears 6 teeth, the second from the front is the largest. The peculiar mediad process above the articulation surface in the mandible of *Monopeltis* is absent in *Leposternon,* in its place there is but a small knob.

4. Adaptive Characters of the Amphisbaenid Skull

All amphisbaenids are burrowing animals. Since they have greatly reduced their appendicular skeleton (except in the genus *Bipes* in which there is a pair of front legs) their primary digging device is the head, in particular the snout, which in the more highly specialized forms, is modified to act as a digging shovel.

The changes that have taken place in the skull in the course of adjustment to subterranean life are interesting. They involve the facial region mainly, but secondarily also the more posterior part of the cranium. In all forms there is an angle — the cranio-facial angle — between the longitudinal axes of the cranium and the facial region. It is much more pronounced in forms with

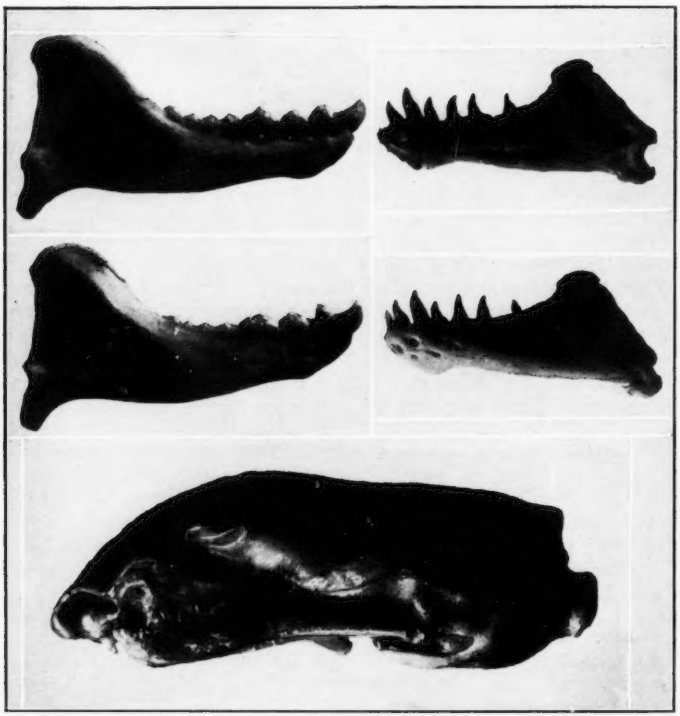

Fig. 18. a, (upper left) photograph of the mandible of *Trogonophis wiegmanni;* upper figure lingual, lower figure buccal aspect. b, (upper right) photograph of the mandible of *Amphisbaena fuliginosa* (spec. "A"). Upper figure lingual, lower figure buccal aspect. c, (lower figure) photograph of the left side of the skull of *Geocalamus acutus*. The stapes with its extracolumella which is connected to some spongy tissue on the lateral surface of the mandible is shown in situ.

shovel-shaped snouts (e.g. in *Geocalamus, Rhineura,* and *Monopeltis*) than in forms like *Amphisbaena.* The primitive amphisbaenid skull was apparently without angulation, a condition most nearly represented by *Amphisbaena ewerbecki* (Fig. 13). One might be tempted to express the amount of the facial bending in angular values.[19] In the primitive condition the cranial and facial axes would form an angle of 0° (no angulation). In *A. ewerbecki* the angle is small, about 5°. In *A. fuliginosa* and in *A. cubana* it is 10°. In *Bipes, Geocalamus* and *Trogonophis* it amounts to roughly 20°, in *Rhineura* to 40° and in *Monopeltis* and *Leposternon* to about 50°.

In forms with shovel-shaped snouts the bones roofing the facial part of the skull are extremely wide and the rostral end of the snout assumes the shape of a spade edge protruding beyond the position of the medial premaxillary tooth. One would expect that this protrusion could be effected simply by an anterior elongation of the premaxilla and the nasal bones. Instead it appears to have been brought about by a rostrad dislocation of the entire roof and the side walls of the skull over a stationary cranial basis. In cases where such a dislocation has not taken place, (i.e. in *Amphisbaena* or *Trogonophis*), the supraoccipital reaches far enough back to shield the foramen magnum and the occipital condyle from the dorsal side (Figs. 12 and 14), the longitudinal axes of the quadrates run approximately parallel to that of the facial region of the skull, the rostral tip of the premaxillary lies immediately above the medial premaxillary tooth, and the external nasal openings are in dorso-lateral position. In forms like *Rhineura, Monopeltis* and *Leposternon* on the other hand, the occipital condyle is visible from above, the quadrates are shorter (!) and stand at a right angle to the main axis of the cranium, the rostral tip extends beyond the unpaired premaxillary tooth, and the nasal openings are on the ventral side of the spade-shaped rostrum. The bones of the basis of the skull are not much affected by this rostrad displacement, with the exception of the posterior processes of the pterygoids attached to the quadrates. These processes are sharply bent outwards (Figs. 15, 16 and 17).

5. Remarks Concerning the Comparative Anatomy of the Amphisbaenid Skull

The amphisbaenid skull exhibits a strange mixture of primitive and highly specialized features. The remarkable preservation of the primordial side walls of the brain case, the direct continuation of the cranial cavity into the nasal cavity, the primitive development of the latter (Fisher, 1900) and the enormous size of the ear capsules, all indicate the primitive nature of this type of skull. On the other hand the almost total lack of dermal elements that in primitive reptiles form the dorso-lateral portion of the skull roof and border the temporal fenestrae and the orbits, the forward advanced position of the quadrato-articular joint, the attachment of the quadrate to the otic capsule rather than to the squamosal, which latter is observed in various stages of reduction in the present material, the peculiar tendinous connection of the

19 It is difficult to define the longitudinal axes, and the angular values are therefore mere approximations.

extracolumella with a tissue cushion on the lateral surface of the mandible, and the distinctly adaptive characters described in the previous section, are no doubt highly specialized features.

It is interesting to compare this condition with that of lizards and snakes. The lacertilian brain case is very incompletely ossified. In the adult large portions of its wall are membranous. In the chondrocranium, primordial side walls in the orbito-temporal region are at least indicated in their original extent by a delicate system of cartilage bars, the taeniae marginales. These are removed dorsad from the roof of the mouth cavity by a high septum interorbitale, developed in conjunction with the great increase in size of the orbits. Compared with that of the amphisbaenids, the lacertilian brain case is highly specialized. The rest of the lizard skull, however, is comparatively primitive. These numerous dermal bones that make up the dorso-lateral part of the skull surface in primitive reptiles, are still present in lizards, however greatly reduced in number and size.

The ophidian chondrocranium is more highly reduced than that of lizards (Peyer, 1912). It lacks (at least in *Tropidonotus natrix* and *Vipera aspis*) a septum interorbitale. As in the amphisbaenid skull there are no lateral arcades of dermal bones extending beyond the brain enclosure proper, no temporal fossae, and the orbital depressions are ventrally open. Thus the snake skull combines the specialized features of both lizards and amphisbaenids, besides having a few of its own (great mobility of the facial bones).

It is generally believed that the complete ossification of the amphisbaenid cranium developed in connection with the fossorial mode of life of these animals. Most of the recent snakes live above ground, but their cranium, too, is completely ossified. Quite recently Walls (1942) advanced strong evidence, based on extensive studies of the visual mechanisms, that the snakes went through a period of fossorial life at one time in their phylogenetic history. But before this happened, the snakes seem to have partly or completely reduced the primordial side walls of the chondrocranium, and when the subterranean habitat called for a complete bony encapsulation of the brain, the parietals and in part the frontals had to substitute for the previously lost primordial side walls of the orbito-temporal region.

The amphisbaenids apparently became fossorial at a much earlier time than the snakes, when their chondrocranium was still fully developed. From that time on they seem to have remained rather conservative. This does not mean that no further processes of specialization took place in the amphisbaenid skull. The general principle of simplification of the skull construction in vertebrates, formulated as Williston's law by Gregory (1935), is well illustrated in the otherwise primitive *Amphisbaena ewerbecki* in which co-ossification and perhaps reduction of some of the cranial components have resulted in a rather simple skull pattern (Figs. 3, 4, and 5). A comparison of the amphisbaenid skull with that of *Lysorophus tricarinatus* Cope, a small vertebrate from the Lower Permian of Texas and other localities, reveals an amazing similarity in shape and fundamental construction of the two forms. *Lysorophus* was carefully studied by Case (1908), Broili (1908), von Huene (1913) and particularly by Sollas (1920) who reconstructed the skull, vis-

ceral skeleton and portions of the postcranial skeleton by means of serial sections (peel method). Broili (1908), considering *Lysorophus* a reptile, compared its skull with that of *Amphisbaena alba* and pointed out the striking similarity between the two forms. The similarity is so great that there is no morphological reason to prevent the direct derivation of the amphisbaenid skull condition from that of *Lysorophus*, except the presence of distinct gill arches in the latter. This fact obviously suggests that *Lysorophus* is an amphibian.

Future work on the embryology of amphisbaenids will have to determine their systematic position. If they are true amniotes, reptiles as has been assumed, a number of questions of profound morphological interest arise.

The question concerning the systematic position of the amphisbaenids cannot be conclusively answered on the basis of present information. It appears certain, however, that they are not closely related to either the lizards or the snakes and should occupy an order by themselves.

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Dodecatheon in Eastern North America

Norman C. Fassett

This paper treats the Shooting Stars, *Dodecatheon,* of the region east of the 100th meridian, *i.e.,* from Minnesota to eastern Texas, and eastward. It is based on field studies in a dozen states, and on material in the following herbaria: the University of Arkansas, the herbarium of Miss Lena Artz, the Brooklyn Botanic Garden, the Carnegie Museum, the herbarium of C. C. Deam, the Field Museum, the Gray Herbarium, Iowa State College, Louisiana State University, the Missouri Botanical Garden, the New York Botanical Garden, the University of Oklahoma, the University of Pennsylvania, the Academy of Natural Sciences of Philadelphia, the University of Tennessee, the University of Texas, Virginia Polytechnic Institute, West Virginia University, and the University of Wisconsin. To those to whom I am indebted for loans I wish to express my appreciation, as well as to those who have responded to many letters of inquiry regarding the plants in the field. Some of those who have contributed valuable information concerning Shooting Stars in various regions are: Dr. Edgar Anderson, Dr. C. E. Allen, Mr. E. F. Bean, Prof. E. Lucy Braun, Prof. Clair A. Brown, Dr. W. H. Camp, Dr. E. L. Core, Dr. J. T. Curtis, Dr. C. C. Deam, Mrs. James L. Dormon, Dr. W. B. Drew, Dr. B. M. Duggar, Dr. R. I. Evans, Miss Flora Fender, Dr. M. L. Fernald, Dr. F. A. Gilbert, Mr. Charles Gore, Dr. J. M. Greenman, Dr. E. M. Gress, Dr. R. M. Harper, Dr. Milton Hopkins, Mr. J. F. Macbride, Dr. A. B. Massey, Dr. Frank T. McFarland, M. R. Metman, the late Mr. C. Z. Nelson, Miss Ruth D. Sanderson, Dr. G. L. Stebbins, Dr. J. A. Steyermark, Miss Alice Strickler, Mr. Hugh E. Stone, Dr. H. K. Svenson, Dr. B. C. Tharp, Dr. E. T. Wherry, and Dr. T. G. Yuncker. A number of others who have assisted materially in the gathering of field data are listed in Appendix I.

1. Taxonomic Treatment

The eastern species of *Dodecatheon* are characterized by having capsules opening by valves, filament-tube light-colored and less than half as long as the anthers, and connectives smooth (sometimes wrinkling slightly in drying). This combination of characters is possessed in the west by the *D. radicatum* group, which, like the rest of the western Shooting Stars, is in a state of utter confusion taxonomically. The writer has observed these plants only to a limited extent in the west. Seven collections from the Black Hills of South Dakota show slender plants with 1-10 brilliantly colored flowers. The slender capsules range in texture from moderately thin-walled like those of *D. amethystinum* to so membranous that the seeds are dimly visible through the capsule walls; the filament-tubes vary from broader than long to narrower than long (but are not as slender as the more western *D. pauciflorum*). Both of

these characters vary within a colony. At present they all seem best treated as *D. radicatum*. Plants of the *D. radicatum* group, as characterized in the opening of this paragraph, occur throughout a wide range in the west, and may actually embrace several species.

The confused state of our knowledge concerning this complex genus in the west may be judged by a comparison of the treatments in various manuals; there is lack of agreement in the fundamental divisions of the genus, and in the names for various concepts, and often quite contradictory statements. One of the many causes of confusion is the intra-colonial variation mentioned above. This habit is stronger in some species, and within a species may be more extreme in one region than another. The experiences of the writer with the intra-colonial variation in *D. Meadia,* and with the varying amounts of such variation in different parts of the range of that species, and his field observations and correspondence with botanists concerning its local behavior which have been required to make any sense out of these variations, convince him that clarification of *Dodecatheon* in the western states should not be undertaken without years of observation in the field.

Dodecatheon is remarkable for the characters which are reliable in many other groups, but are here quite fickle, and for the gain as well as the loss of some characters when the plants are pressed. The kinds of characters may be discussed in four categories, as follows:

1. Field characters lost in pressing. One of the best diagnostic characters lies in the color of the corolla-lobes (the shades and designs of the brilliant markings on the short corolla-tubes are unique on each plant). *D. Meadia,* in the northern part of its range, grades in flower-color, within each colony, from lavender or lilac to white. Southward there is usually less variation within a colony. *D. amethystinum* has a deep purple to magenta or almost crimson corolla; it is usually just the color of a potassium permanganate solution. Fresh flowers have been compared with a $KMnO_4$ solution, and kodachromes of this species, of *D. radicatum* from the Black Hills, and of what is probably *D. acuminatum* from the Big Horn Mountains, show just the same color. There is no gradation to white; albino individuals of *D. amethystinum* have been observed but twice by the writer in a dozen years of experience with the plant. But, after pressing, the color of these three species becomes dark blue or white, and is indistinguishable from that of *D. Meadia.*

2. Herbarium characters which are unreliable in the field. All herbarium specimens of *D. Meadia* (with certain exceptions to be discussed later) show, at the base of the leaves, a distinct reddish tinge or red flecks. Herbarium specimens of *D. amethystinum* lack this red marking on the leaves. But an occasional living individual of *D. amethystinum* shows fully as much red coloring as do some of those of *D. Meadia.* The character is often worthless in the field, but of great value in the herbarium, because the red-tinged individuals of *D. amethystinum* lose their color when they are pressed. The red pigment has been extracted by Professor B. M. Duggar, and it was observed that while it disappears from the leaves of *D. amethystinum* as soon as they

are dipped in hot water, leaves of *D. Meadia* retain some color even after boiling for three hours.

3. Characters reliable in both field and herbarium. The texture and color of the fruit seem to be best. *D. Meadia* has a stout dark red capsule with firm thick subligneous walls, while *D. amethystinum* has a slender light yellowish-brown or ashy capsule with thin walls. As noted above, what appears to be *D. radicatum* in the Black Hills has a capsule with membranous walls; the value of this character cannot be judged on the basis of present knowledge.

4. Characters valueless in both field and herbarium. The examination of a large suite of specimens, or the study of individuals in any colony, show a surprising number of characters which would be expected to be of taxonomic importance, but are actually worthless. The shape of the connectives has been relied upon by Small in his treatments of the southern members of this genus, but these vary in almost any colony from lanceolate to ovate, and the striking broad connectives of the type specimen of *D. Hugeri* can be duplicated by many individuals throughout the range of *D. Meadia;* it is the present writer's observation that connective shape in *D. Meadia* is variable and shows no correlation with other characters or with geographic range, and it is his opinion that species based on shape of the connective are invalid. Plants with separate filaments occur sporadically throughout the ranges of *D. Meadia* and of other species with filaments typically united; occasionally a single flower with free filaments ocurs in an umbel in which the rest of the flowers have united filaments.

The yellow markings on the corolla-tube show great variation from plant to plant, with a reasonable uniformity on the flowers of one plant. The length and proportions of the corolla-lobes are essentially uniform on the flowers of each plant, but vary widely on the plants of any one colony. Tracings of a corolla-lobe from each of 14 specimens from Wisconsin are shown in Fig. 9.

The leaves vary from spatulate to ovate in almost any colony. They may exceed the scape or be only a fraction of its length, and may be erect or spreading; these traits appear to be to some extent correlated with habitat. Fig. 10 shows tracings of leaves from a number of specimens from Wisconsin. In certain western species the length of the leaves appears to be of some diagnostic value, but not in the eastern ones. The writer, visiting the wildflower garden of Mrs. James Dormon at Shreveport, Louisiana, was impressed by the conspicuous callous-tipped teeth on the leaf-margins of many plants. In June, 1937, Mrs. Dormon sent a large number of fresh leaves to Madison, where they were compared with those of living plants in the University of Wisconsin Arboretum. No constant difference could be found; callous-tipped teeth were as frequent on the Wisconsin plants as on those from Louisiana, and both sets of leaves varied widely in shape and nature of the margin. The callous-tipped teeth are not as conspicuous in pressed plants as they are in the living ones.

The 14 species of *Dodecatheon* described by Rafinesque[1] are based primar-

1 Atl. Journ. **1**:179-180. 1833.

ily on shape of leaves. They are quite unidentifiable from the descriptions and are probably all *D. Meadia*. The only possibility of there being any prior name in the group is the remote chance of one of these names belonging to *D. amethystinum*.

KEY TO THE DODECATHEON EAST OF THE 100TH MERIDIAN

A. Capsule stout, mostly less than 3 times as long as broad, dark reddish brown, with walls of firm ligneous texture 130-325 microns thick; living flowers with corolla-lobes ranging from lilac to white with many pale intermediates; leaves marked with red at base even in pressed specimens (except in rare forms from southern Illinois to Texas) ..... 1. *D. Meadia*

B. Leaves tapering to the base C
C. Tube of filaments 1-2 mm. long D
D. Capsule 2-3 times as long as thick E
E. Calyx-lobes on expanding flowers 3-7 mm. (mostly 4-5 mm.) long, and on fruits 4-9 mm. (mostly 5.5-7 mm.) long; anthers 6.5-10 mm. (mostly 7-8 mm.) long; capsules 10.5-18 mm. long; flowers 4-125 on each plant F
F. Leaf-bases marked with red ..... 1a. var. *genuinum*
F. Leaf-bases not marked with red ..... f. *sedens*
E. Calyx-lobes on expanding flowers 2.5-5.0 mm. (mostly 3.5-4.0 mm.), long, and on fruits 4-4.5 mm. long; anthers 4-7 mm. (mostly 5.5-6.5 mm.) long; capsules 7.5-10 mm. long; flowers 1-14 on each plant G
G. Leaf-bases marked with red ..... 1b. var. *brachycarpum*
G. Leaf-bases not marked with red ..... f. *pallidum*
D. Capsule nearly as thick as long ..... 1c. var. *obesum*
C. Tube of filaments 2-3 mm. long ..... 1d. var. *Stanfieldii*
B. Leaves with blades cordate or abruptly narrowed to the petiole ..... 1e. var. *Frenchii*

A. Capsule cylindrical, mostly more than 3 times as long as broad, light brown or yellowish, with thin walls of almost papery texture 35-120 microns thick; living flowers with corolla-lobes deep rose-purple, or rarely white but without a series of intermediates; leaves rarely marked with red in living plants and without red markings in pressed specimens; calyx-lobes about 1/3 as long as the expanding corolla (measuring each from the base of the calyx lobes), 2-5 mm. (mostly 3 mm.) long on expanding flowers, and on fruits 3-6 mm. (mostly 4-5 mm.) long; anthers 5.0-7.5 mm. long ..... 2. *D. amethystinum*

H. Corolla-lobes red-purple
I. Corolla-lobes reflexed ..... f. *typicum*
I. Corolla-lobes directed forward ..... f. *Stricklerae*
H. Corolla-lobes white ..... f. *margaritaceum*

1. D. MEADIA L., Sp. Pl. 1:144. 1753. *D. Meadia* subsp. *a eumeadia* R. Knuth, in Pflanzenreich 4: fam. 237: 237. 1905. *D. Meadia* f. *album* Macbride, in Field Mus. Pub. 278, Bot. Ser. VIII, no. 2: 129. 1930(as f. *alba*). *D. Hugeri* Small, Fl. Southeastern U.S. 906 & 1336. 1903. *D. Meadia* subsp. *Hugeri* R. Knuth, *l.c. D. lutescens* C. Z. Nelson, in Nat. Hort. Mag. 2:16. 1923.

Linnaeus based *Dodecatheon Meadia* on the descriptions and plates of Catesby and of Plukenet. The Catesby plate shows pinkish or purplish corollas (the color varying in different editions), coarsely toothed leaves, and about 17 flowers on a coarse plant. The calyx-lobes are rather too deltoid for *D. Meadia* but appear not to have been very carefully drawn. The capsule is that of *D. Meadia* var. *genuinum* as interpreted in this paper, and the plant

is said to have come from "beyond the Apalatchian mountains." The plate certainly represents *D. Meadia* var. *genuinum*.

The figure of Plukenet is unquestionably *Dodecatheon*, but specific characters are not well shown. The description specifies white flowers, but the "albis" was omitted by Linnaeus, presumably on the strength of Catesby's colored plate. The Plukenet reference probably represents, then, *D. Meadia* f. *album*, the white-flowered phase of var. *genuinum*.

D. Meadia f. *album* was described from northern Illinois. Most of the varieties of *D. Meadia* have a colored and a white phase; it does not seem necessary to name each of them.

D. Hugeri was distinguished as follows:[2]

Connective-body lanceolate: corolla typically pink-purple ..... 1. *D. Meadia*
Connective-body ovate: corolla typically white ..... 2. *D. Hugeri*

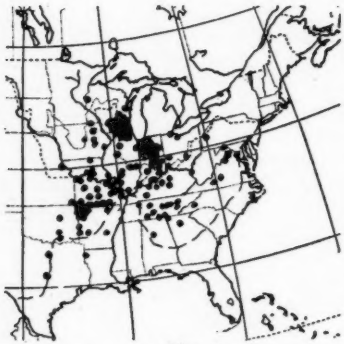
The abruptly narrowed connective-bodies of the type of *D. Hugeri* are in striking contrast to the lanceolate ones of most specimens of *D. Meadia*, but similar ovate connective-bodies may be found sporadically throughout the range of *D. Meadia*. In fact, of 71 flowering specimens from Wisconsin in the Herbarium of the University of Wisconsin, 13 are good matches for the type of *D. Hugeri* on this character. The corolla-lobes of *D. Meadia* are described by Small as being 1-1.5 cm. long, and those of *D. Hugeri* as 1.5-2 cm. long; actually they vary, in Wisconsin alone, from 1-2.7 cm. in length (see Fig. 9).

As for the purported difference in flower color between *D. Meadia* and *D. Hugeri*, in his text Small emends the description of the former to read "pink-purple or almost white," while the latter becomes "white or delicately tinged with purple." The writer has studied the variations in color of these flowers throughout much of the area from Wisconsin to Kentucky and Louisiana, and written many letters of inquiry to botanists familiar with the plants in the field. The facts are as follows. Southward, most colonies of *D. Meadia* consist of all, or nearly all, white-flowered plants, or else of all colored-flowered plants, while northward both white and colored flowers occur in every colony. The details and significance of these facts will be discussed later (page 479). From the standpoint of taxonomy, they indicate that there is but one species here. True, a colony of shooting-star in a glade in southern Missouri or along a cliff in Arkansas, made up entirely of plants with alabaster-white flowers (except for the always yellow-and-orange eye), looks very different from a patch in Wisconsin or northern Illinois, whose flowers show every shade from pure white to deep lilac. But the difference is in the colony, not in the individual plants; a white-flowered individual of var. *genuinum* from Arkansas is not distinguishable from a white-flowered individual from Wisconsin.

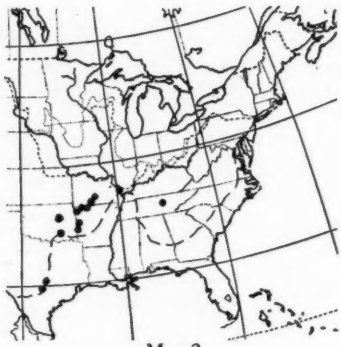
D. lutescens C. Z. Nelson was described as having the corolla pale yellow

2 Small, Man. Southeastern Flora 1027. 1933.

with a brown ring at the base; it came from ravines along Otter Creek, 32 miles southwest ("northwest" in the original description) of Louisville. This is a few miles west of Fort Knox, Kentucky. I have explored the banks of Otter Creek, following directions for finding this plant as given to me by Mr. Nelson. It has apparently been exterminated by pasturing of hogs. Individuals of *Dodecatheon* found a few miles northeast of Fort Knox had the flowers white or pale lilac. In the spring of 1937, Mr. Nelson sent me a fresh flower from a plant of *D. lutescens* growing in his garden; to me this flower appeared to have only white corolla-lobes, with no yellow color except for that



Map 1



Map 2

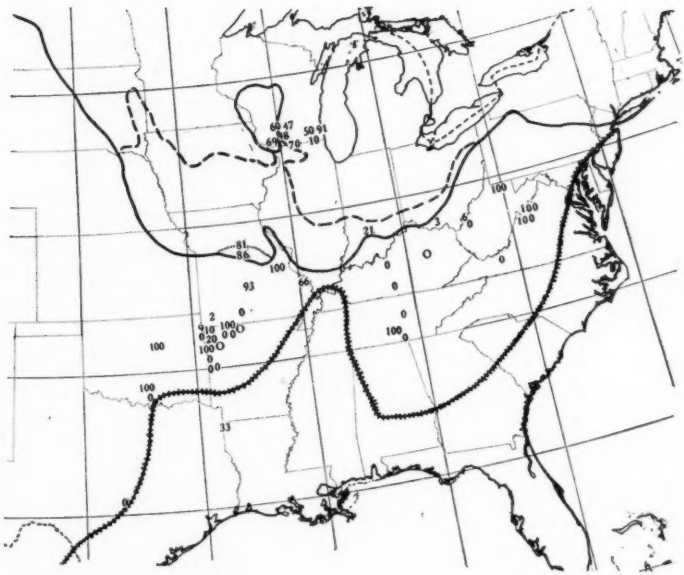
Map 3

Map 4

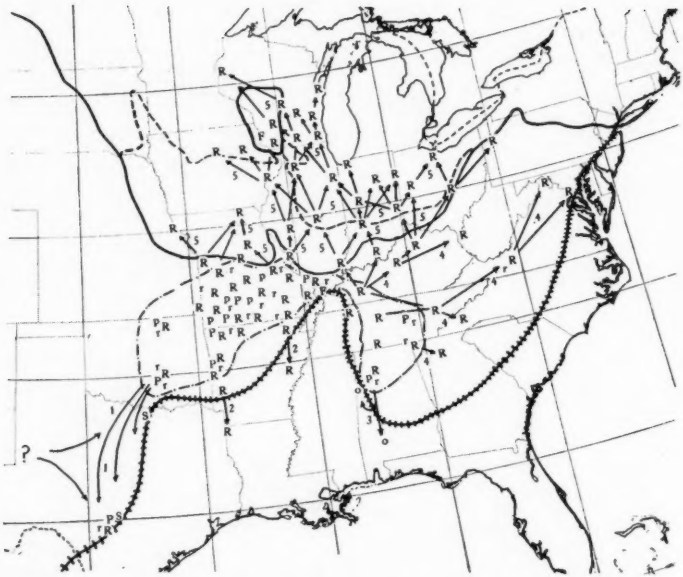
Map 1. Range of *Dodecatheon Meadia* var. *genuinum*. Map 2. Range of *Dodecatheon Meadia* f. *sedens*. Map 3. Range of *Dodecatheon Meadia* var. *brachycarpum*. Map. 4. Range of *Dodecatheon Meadia* var. *brachycarpum* f. *pallidum*. Map 5. Ranges of varieties of *Dodecatheon Meadia*—dots: var. *Frenchii*; circles: var. *obesum*; crosses: var. *Stanfieldii*. Map 6. Range of *Dodecatheon amethystinum*.

Map 5

Map 6

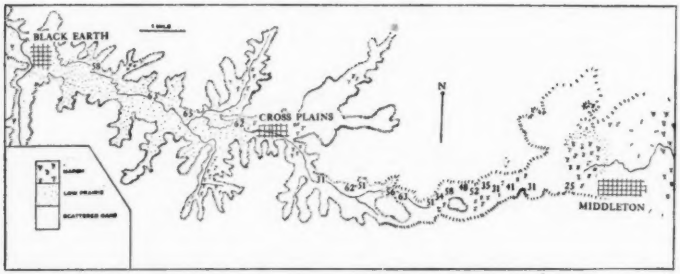


Map 7. Figures: percent of plants with colored flowers, in each colony of *D. Meadia*. The broad zero signifies a figure of less than 1%. Heavy solid line: southern limits of Pleistocene glaciation, and the Driftless Area. Heavy broken line: southern limits of Wisconsin glaciation. Cross-marked line: northern edge of the Coastal Plain.



Map 8. Heavy solid lines, heavy broken line, and cross-marked line, as in Map 7. Dash-dot line encloses ancient uplands where several varieties and forms of *D. Meadia* occur. R: *D. Meadia* var. *genuinum.*; P: *D. Meadia* f. *sedens*; r: *D. Meadia* var. *brachycarpum*; p: *D. Meadia* var. *brachycarpum* f. *pallidum*; S: *D. Meadia* var. *Stanfieldii*; F: *D. Meadia* var. *Frenchii*; o: *D. Meadiai* var. *obesum*; Arrows: migrations of *D. Meadia*. The figures indicate the approximate order of these migrations.

Base maps are from Hall's "Outline Maps and Graphs," published by John Wiley & Sons, Inc.



Map 9. Figures: percent of plants with colored flowers, in each colony of *D. Meadia*, between Black Earth and Middleton, Wisconsin.

at the base of the tube. Since Mr. Nelson's death his herbarium has been incorporated with that of the University of Wisconsin. The type specimen of *D. lutescens* has the filaments free, not a common condition in *D. Meadia*, but one occurring in several specimens from widely separated localities, and often appearing on some of the flowers in an inflorescence. The color of the corollas is faded beyond recognition, but a few expanding buds show a suggestion of lilac.

1a. **D. Meadia** var. **genuinum.** *D. Meadia* L. District of Columbia and western Pennsylvania to western Wisconsin, eastern Iowa, southeastern Nebraska, and south to northern Georgia, Alabama, northwestern Louisiana, and eastern Texas. Map 1. This is the only representative of the genus in glaciated territory. Its habitat in Wisconsin was probably originally oak openings, which, according to the records of the surveyors of a century ago, constituted perhaps the most common vegetational type in southern Wisconsin. With a primary preference for these park-like woods, its tolerance extends from open prairie on the one hand to forest (but by no means climax forest) on the other. It is found, in Wisconsin, on low prairies or meadows, or on steep open hillsides with *Petalostemum, Bouteloua,* and other typical prairie plants. The gravel hills which are covered with Pasque flower in early spring are often overspread with Shooting Star by the end of May. With other prairie plants it often abounds along railroads.

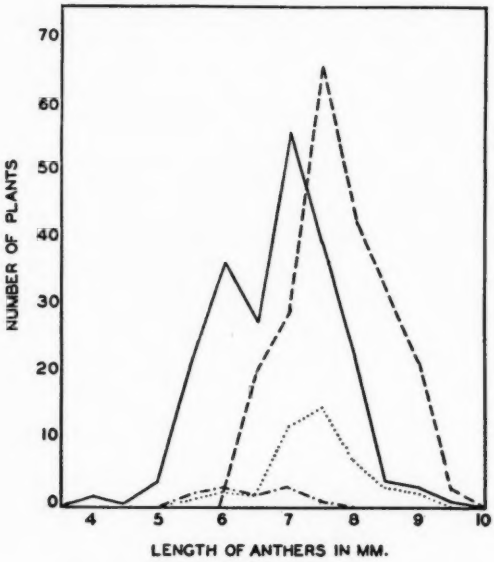
Southward it occurs through the prairie regions of Iowa, Missouri and Illinois. In southern Illinois and northern Kentucky it becomes a woodland plant, and in Arkansas, while it is sometimes found on prairies, it is also characteristic of wooded cliffs and of densely wooded stream banks.

Besides being the only Shooting Star of glaciated regions, this variety alone has spread to the Coastal Plain of Arkansas and Louisiana.

Some specimens, closely matching *D. Meadia* var. *genuinum,* from "Oregon" with no precise location, collected by Rev. Mr. Spaulding, are large and robust, with anthers 9 mm. long; the exact status of these plants cannot be determined from the scanty material. The sheets are located at the Missouri Botanical Garden.

D. Meadia f. **sedens,** n.f., formam *genuinum* simulans sed foliis basi non rubescentibus. TYPE from Forsythe, Missouri, April 19, 1938, *Edith Seymour Jones,* in Herb. Univ. of Wis. Occurring locally, usually with var. *genuinum* and often with var. *brachycarpum,* from Tennessee to Oklahoma and Texas. Map 2. This form will be discussed under *D. Meadia* var. *brachycarpum* f. *pallidum.*

1b. **D. Meadia** var. **brachycarpum** (Small) n. comb. *D. brachycarpa* Small, Fl. Southeastern U. S. 906 & 1336. 1903. *D. Meadia* subsp. γ. *brachycarpum* R. Knuth, l. c. Missouri, eastern Oklahoma and Arkansas, eastward to northwestern Alabama, Tennessee and Virginia, southwestward to the Balcones Escarpment, Texas. Map 3.



———— *D. Meadia* in Missouri, Arkansas and Oklahoma.
..... *D. Meadia* from Gray Summit, Missouri.
—.—.—. *D. Meadia* from Mena, Arkansas.
— — — — *D. Meadia* from Wisconsin.

This small-flowered and small-fruited phase of *D. Meadia,* occurring in the uplands south of glaciation, usually grows with the more robust var. *genuinum* and often grades into it. Under these circumstances its recognition as a species is quite without justification. However, when the anther-length is recorded from all the available specimens of *D. Meadia, sensu lato,* from Oklahoma, Missouri and Arkansas,[3] and graphed to show the frequency of each length class, the solid line on Graph 1 is the result. The two peaks in this curve indicate that the plants actually consist of two partially distinct populations. Had the graph representing these plants formed two nearly or quite separate curves the treatment of the group as two species might have

3 The writer is fortunate in having had ample material from these regions where the problems of classification in *D. Meadia* are most difficult. Dr. Julian A. Steyermark has had these problems in mind for several years and has made large collections and careful notes without which this study would scarcely have been possible. Dr. Milton Hopkins has made special efforts to collect material of this genus. Visits to southern Missouri and western Arkansas have enabled the writer to collect and observe the living plants for a number of years, and these collections have been augmented by those of Dr. V. M. Watts, Dr. D. M. Moore, and Dr. Etlar Nielsen. Dr. Edgar Anderson has contributed a mass collection of flowers from the Missouri Botanical Garden Arboretum at Gray Summit.

been justified. The weakly bimodal curve indicates that there are two populations, maintaining themselves only partly isolated genetically from each other. Taxonomically this relation is best represented by the varietal designation.

In the actual identification of specimens, there will be difficulty in placing some of the intermediates. The naming of many of the individuals must be on a summation of all the characters presented in the key.

The variation in size of floral parts ranges almost as widely in any colony as it does in the whole region. This is indicated by the dotted line curve on Graph 1, which represents 34 flowers, each from a different plant, collected at Gray Summit, Missouri; the anther lengths range from 5.5-9.0 mm., as compared to a range of 4.0-9.5 mm. in all Missouri, Arkansas and Oklahoma. Being at the northern edge of the range of var. *brachycarpum,* this colony shows fewer of the small flowers. A small collection (11 plants) from a brookside north of Rich Mt., near Mena, Arkansas, is shown by the dot-dash line; even these few individuals show a range in anther length from 5.5 mm. to 7.5 mm.

As might be expected, *D. Meadia* var. *genuinum* from Wisconsin, where var. *brachycarpum* is absent, shows a curve (broken line, Graph 1) with a higher minimum length than does the total from the region where the small-flowered populaton is intermixed. The maximum is the same as in the more southern group, and the mode is only slightly higher; this signifies that the Wisconsin population does not differ qualitatively from some elements of the Oklahoma-Arkansas-Missouri one, but merely lacks the small-flowered element present in the south.

D. Meadia var. **brachycarpum** f. **pallidum,** n.f., foliis fructubusque var. *brachycarpum* simulans, sed foliis basi non rubescentibus. TYPE from Pettigrew, Arkansas, April 17, 1940, *N. C. Fassett & D. M. Moore,* no. 21560, in Herb. Univ. of Wis. Throughout the range of var. *brachycarpum* and often occurring wth it. Map 4. Presence or absence of red markings on the bases of leaves of *Dodecatheon Meadia* is not ordinarily a response to conditions. Throughout its range in the glaciated areas, *D. Meadia* has red leaf-bases wherever it grows. In most of the range of var. *brachycarpum* both red leaf-bases and pale leaf-bases occur together in the same habitat. One case has been observed, however, where an extreme condition influenced the production of red pigment. On the bluffs and cliffs along the Big Piney River at Devils Elbow, Missouri, on April 18, 1938, a large majority of the plants were seen to lack red leaf-bases. Some of those which did show pale red were collected and pressed; as this is written (December, 1941) the color is still evident on 5 of these individuals and has faded on 4 of them. A few rosettes grew in a small stream of cold water which trickled over the cliff, and these showed a strong red pigmentation in the leaf-bases, and this pigmentation has persisted on the 6 individuals which were pressed. It is concluded that while degree of development of red pigment is not ordinarily dependent upon an

ecological factor, such an extreme factor as constant bathing in cold water may cause an abnormal degree of coloring.

So much for the taxonomic status of these phases of *D. Meadia;* their distribution throws some light on the past migrations of the species, and will be discussed in another place (pages 480-481).

1c. **D. Meadia** var. **obesum,** n. var., capsulis ovoidis, 9-10 mm. longis, 4-9 mm. diametro. TYPE from prairies, Wilcox County, Alabama, 1841, *S. B. Buckley,* in Herb. New York Botanical Garden. The following also appears to belong here: from a garden in Washington, D.C., the plants originally from Marion County, Alabama, May, 1937, *E. T. Wherry.* Map 5, open circles. This variety of *Dodecatheon Meadia,* based on but two specimens, one of them a century old and the other from a garden, must be regarded with uncertainty until it is better known in the field. The type specimen shows at least 6 fully mature capsules, which are nearly as broad as long, while those of the other plant have capsules 7-9.5 mm. long and 4.5-5 mm. broad.

Var. *obesum* appears to be a local offshoot from the *genuinum-brachycarpum* complex, occurring on the Coastal Plain in Alabama.

1d. **D. Meadia** var. **Stanfieldii** (Small) n. comb. *D. Stanfieldii* Small, Fl. Southeastern U. S. 906 & 1136. 1903. Texas: San Marcos and vicinity, spring, 1896, *S. W. Stanfield* (TYPE in Herb. N. Y. Botanical Garden); creek bank in woods, Paris, April 27, 1927, *E. McMullen* (in Herb. Univ. of Texas). Map 5, x's. Small distinguished this on the shape of the connective-bodies and of the corolla-lobes, neither of which seem to be at all different from those of dozens of plants of var. *genuinum.* This appears to be the only occurrence, east of the 100th meridian, of plants with the long filament-tubes characteristic of *D. pauciflorum* and other western species.

The range of *D. Meadia* extends southward from the Ozark and the Arbuckle Mountains, into Texas in a very narrow tongue following seepy ledges of the Balcones Escarpment, where Professor B. C. Tharp tells me it is a very rare species. Along this escarpment it varies to f. *sedens;* var. *brachycarpum,* and var. *Standfieldii.*

1e. D. MEADIA var. FRENCHII Vasey, Gray's Manual, ed. 6: 735b. 1891. *D. Meadia* subsp. *membranaceum* R. Knuth, *l. c. D. Frenchii* Rydb., Fl. Prairies & Plains 626. 1932. Known only from the "Illinois Ozarks," or Shawneetown Ridge, in southern Illinois south of the limit of Pleistocene glaciation, and apparently from the Driftless Area in Wisconsin. Map 5, dots. Fig. 11. A specimen from "Fern Rocks" near Makanda, Illinois, May, 1871, *G. H. French,* in the Field Museum, has been marked "Type," presumably by

EXPLANATION OF FIGURES

Figs. 1-8 were drawn by Professor R. I. Evans. All but those of mature capsules are from living material. All are natural size. Figs. 9-17 were traced by the writer from pressed material, which in some cases has suffered some shrinkage. They are ×½.

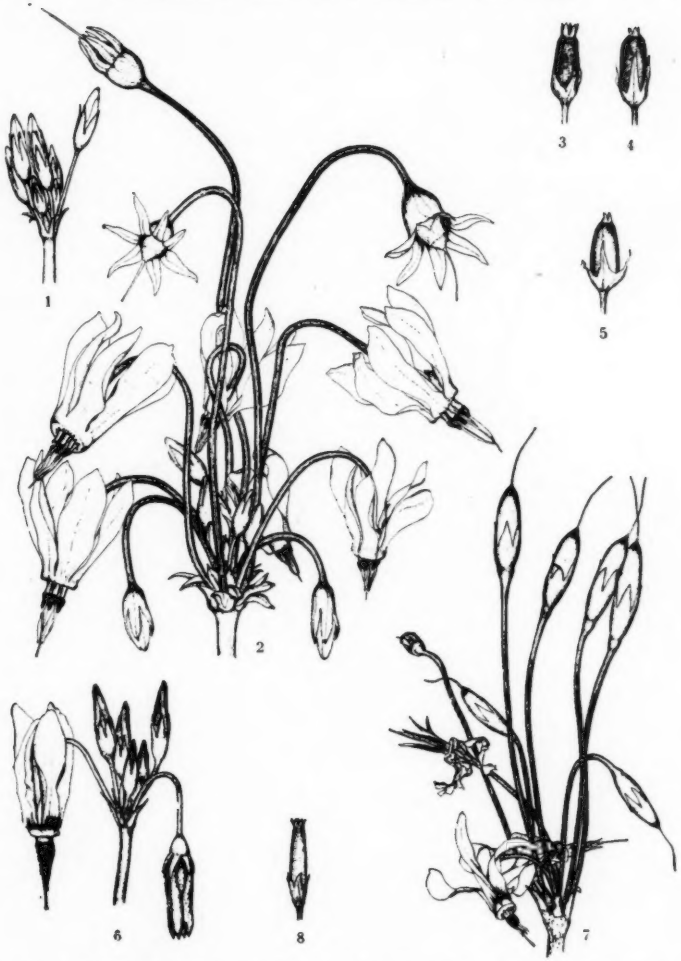


Fig. 1. *D. Meadia* var. *genuinum*. Young inflorescence, as it appears in the vicinity of Madison, Wisconsin, about the middle of May.

Fig. 2. *D. Meadia* var. *genuinum*. Inflorescence, as it appears in the vicinity of Madison, Wisconsin, about the first of June.

Figs. 3-5. *D. Meadia* var. *genuinum*. Mature capsules.

Fig. 6. *D. amethystinum*. Young inflorescence, as it appears when grown in the vicinity of Madison, Wisconsin, about the middle of May.

Fig. 7. *D. amethystinum*. Inflorescence, as it appears when grown in the vicinity of Madison, Wisconsin, about the first of June.

Fig. 8. *D. amethystinum*. Mature capsule.

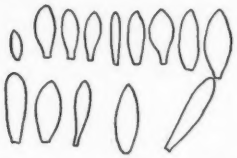


Fig. 9. *D. Meadia* var. *genuinum*. Shapes of corolla lobes, traced from Wisconsin specimens.

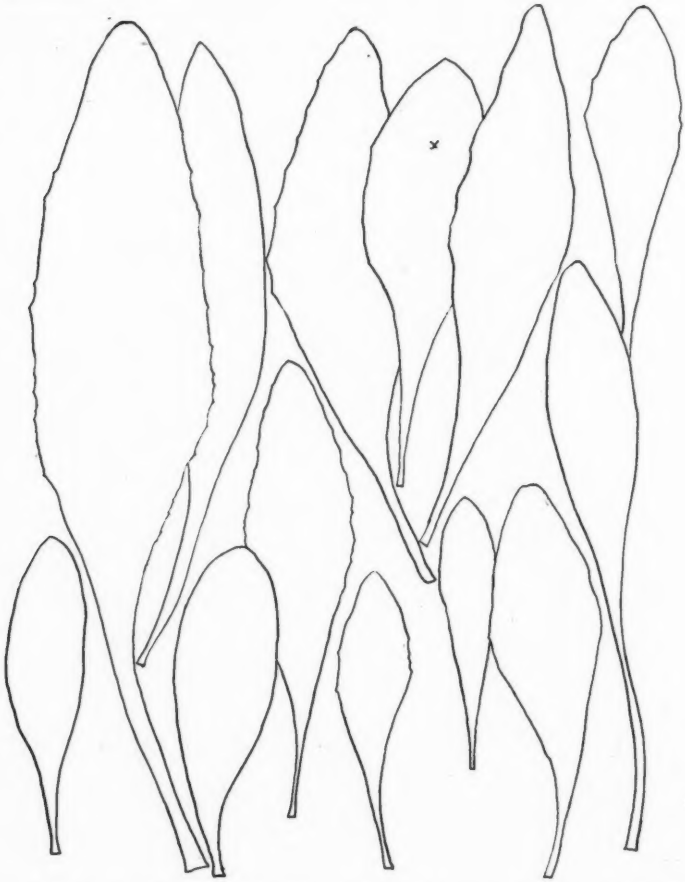


Fig. 10. *D. Meadia* var. *genuinum*. Shapes of leaves, traced from Wisconsin specimens.

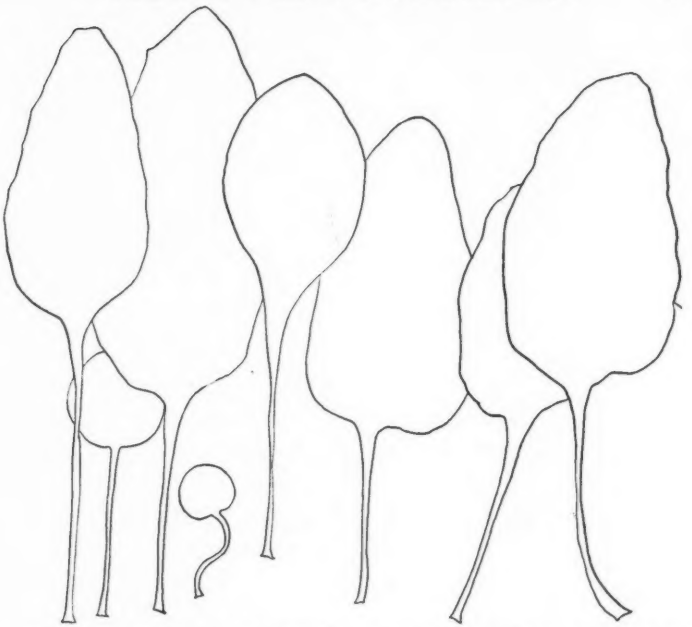


Fig. 11. *D. Meadia* var. *Frenchii*. Shapes of leaves, traced from plants collected in Giant City State Park, Illinois.

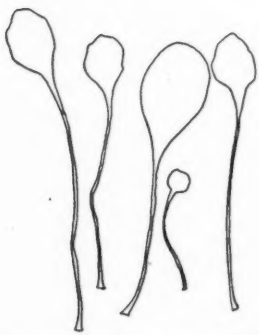


Fig. 12. *D. Meadia* var. *Frenchii*. Shapes of leaves, traced from plants originally collected at Giant City State Park, Illinois, and grown at Madison, Wisconsin, with 1/10 of the normal light.

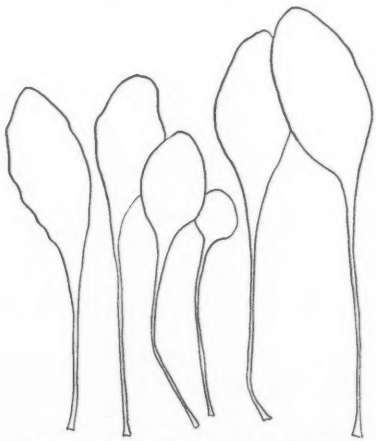


Fig. 13. *D. Meadia* var. *Frenchii*. Shapes of leaves, traced from material described under Fig. 12, but grown in normal light.

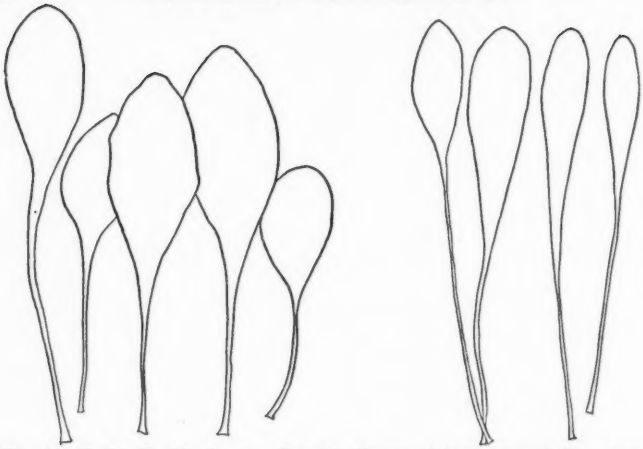
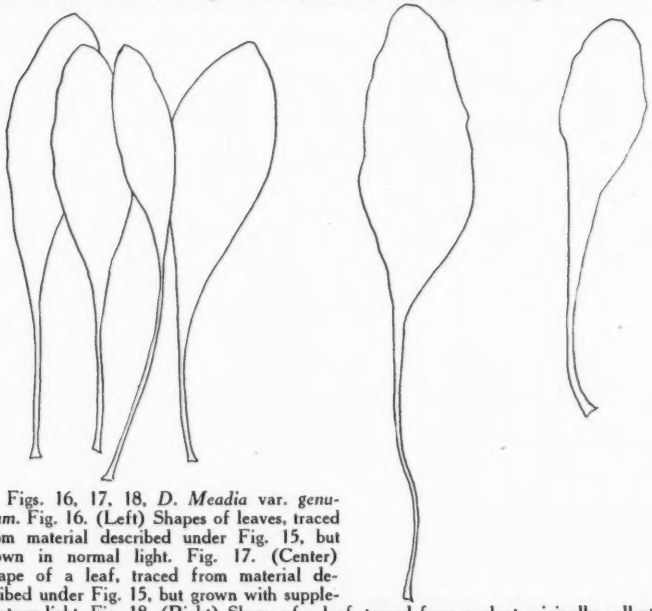


Fig. 14. (Left) *D. Meadia* var. *Frenchii*. Shapes of leaves, traced from material described under Fig. 12, but grown with supplementary light. Fig. 15. (Right) *D. Meadia* var. *genuinum*. Shapes of leaves, traced from plants originally collected at Waunakee, Wisconsin, and grown at Madison with 1/10 normal light.



Figs. 16, 17, 18, *D. Meadia* var. *genuinum*. Fig. 16. (Left) Shapes of leaves, traced from material described under Fig. 15, but grown in normal light. Fig. 17. (Center) Shape of a leaf, traced from material described under Fig. 15, but grown with supplementary light. Fig. 18. (Right) Shape of a leaf, traced from a plant originally collected at Makanda, Illinois, and grown in Madison, Wisconsin, with 1/10 of the normal light.

Mr. Macbride, who has referred to it as the type.[4] Vasey did not, as far as I can ascertain, designate a type, but it seems logical so to consider this sheet. This specimen, when examined with a strong lens, shows a dense covering of minute glands, but individuals of var. *genuinum* often show a similar glandular covering, and nearly all the living plants have it to some extent, especially when young. Presence or absence of glands, or amount of them, does not seem to be a reliable character in the eastern representatives of *Dodecatheon*.

Leaves with blades more or less abruptly narrowed to the petiole occur throughout the range of var. *genuinum*, but extreme plants with broad oval subcordate blades — as Macbride states, one on the type is 5 cm. wide and 6 cm. long — occur only in the two regions named above. The inclusion of all plants with leaves tending to be abruptly narrowed to the petiole has led to various interpretations of the range as much wider than it is: Vasey gave it as "Penn. to S. Ill. and Ark." Some dwarf individuals in the Gray Herbarium from Kentucky (near Ohio R., *Lesquereux*), which are *D. amethystinum*, were marked by Vasey as "var. *Frenchii*," and by Gray "var. *brevifolium*!". The blades are rather wide in relation to their length, but are not at all like the subcordate ones of the plant of southern Illinois. Again, Rydberg in the Flora of the Prairies and Plains gives the range as "Ill. – Minn. – Ark. – Pa. (?)"; in Minnesota the only *Dodecatheon* is *D. amethystinum*, which may have the blade rather abruptly narrowed but does not approach *D. Meadia* var. *Frenchii*. The present writer once reported var. *Frenchii* from Milwaukee, Wisconsin.[5] The report was based on a plant bearing the leaf marked with an "x" on Fig. 10; comparison of this leaf with those of var. *Frenchii* as illustrated in Fig. 11, shows it to belong with var. *genuinum*.

On May 14, 1937, with permission of the Illinois Department of Public Works and Buildings and under the helpful guidance of Mr. Charles Gore, Park Custodian, the writer, in company with S. C. Wadmond, J. T. Curtis, and D. W. Dunlop, made a study of the Shooting Stars at Giant City State Park, near Makanda, Illinois. *D. Meadia* var. *genuinum* had nearly all white flowers in some places, and predominantly colored ones in others. In shaded spots, mostly under overhanging dripping cliffs, this was replaced by or graded into var. *Frenchii*. Extreme development of cordate blades was always well under the cliff, and plants on the summit of the same cliff usually had the leaf of var. *genuinum*. In an attempt to determine to what extent the peculiar leaf shape is genetic, and how much a response to shade or to dripping water, the writer, in January, 1938, secured a few plants from a cliff at Giant City Park where var. *Frenchii* had been seen the preceding spring. These were grown in the greenhouse at Madison, Wisconsin, with the following results: plants grown in full light, with artificial illumination at night to compensate for the short day, had leaves nearly like those of var. *genuinum*. Plants grown under a fine spray of water under full light were also a close match for var. *genuinum*. Plants grown in partial shade, both with and without constant dripping water, showed a strong tendency to var. *Frenchii*. Plants of var.

4 J. F. McBride, Field Mus. Pub. 278, Bot. Ser. VIII, No. 2: 129-130. 1930.
5 Rhodora **29**:233. 1927.

genuinum collected in early April, just as the leaves were starting to expand, on a prairie near Blue Mounds, Wisconsin, and grown under the same sets of conditions, showed no tendency toward a *Frenchii* type of leaf. These were not controlled experiments, for they were not carried on at just the same season and under the same lighting conditions, but they served to indicate that the shape of leaf found on var. *Frenchii* is a response to reduced light and not to the dripping water with which it is often associated.

The next year the experiment was repeated with more carefully controlled conditions. Resting plants, consisting of buds and roots, were obtained as follows: var. *Frenchii* from a cliff at Giant City State Park; var. *genuinum* from a lightly wooded ledge a mile west of Makanda, Illinois; var. *genuinum* from a prairie hillside near Waunakee, Wisconsin. Each collection was divided and grown under three conditions, as follows: in a cheese-cloth tent which admitted about 10% of the normal light in the greenhouse, as measured by a Weston Leicameter; in the full light of the greenhouse; in the light of the greenhouse supplemented by a 200-Watt bulb suspended at about a meter above the plants and turned on during the night and on dark days. They were planted on January 4, 1939, and grew until February 17, 1939. There were 192 hours of sunlight during this period, an average of 4.2 hours per day, which was about 43% of the possible hours of sunlight.[6]

Figures 12-18 show characteristic leaves from such sets of plants. Var. *Frenchii,* when grown in reduced light, had blades abruptly narrowed to a long petiole (Fig. 12), much like those grown under natural conditions (Fig. 11). Under "normal" light, which was of course much less than the plants would have received in southern Illinois several months later, they were more tapered at base in most cases (Fig. 13). With supplementary light they were almost like var. *genuinum* (Fig. 14). The production of the leaves of var. *Frenchii* is, then, to a large extent a reaction to the reduced light of its habitat.

Although var. *Frenchii* turns into var. *genuinum* when it is grown under intensified light, var. *genuinum* does not turn into var. *Frenchii* when it is grown under reduced light. Plants from a prairie near Waunakee, Wisconsin, when grown in the cheesecloth tent had attenuated leaves (Fig. 15) but did not approach var. *Frenchii.* These prairie plants when grown with normal light (Fig. 16) and with supplementary light (Fig. 17) were mostly quite typical of var. *genuinum* (cf. Fig. 10).

It is apparent, then, that while the peculiar shape of the leaf of var. *Frenchii,* found in nature only under overhanging cliffs, is a result of the reduced light in that habitat, not all of *D. Meadia* responds in this way to reduced light; only the plants of certain localities do so. In other words, *D. Meadia* var. *Frenchii* differs genetically from the wide-spread phases of *D. Meadia,* but special ecological conditions are required for a phenotypic expres-

6 Computed from the Monthly Meteorological Summaries for January, 1939, and February, 1939, prepared under the direction of Eric R. Miller, Meterologist, U. S. Weather Bureau, Madison, Wisconsin.

sion of the varietal condition. Records of similar cases are not rare: for example, *Primula sinensis rubra* when reared at 30-35° C. has white flowers, and when reared at 15-20° C. has red flowers; *P. sinensis alba* always has white flowers without respect to the temperature at which it was reared. "The constant difference between these races is not in their color, but in the possibility of producing specific colors at certain temperatures."[7]

To discover if the potentiality of producing var. *Frenchii* might be general in the plants of the Illinois Ozarks, I took plants from a lightly wooded ledge about two miles west of the cliff where var. *Frenchii* had been secured. These plants, when reared in reduced light, reacted (Fig. 18) as had the individuals from the Wisconsin prairie, and showed little or no approach to var. *Frenchii*. This variety seems, then to be closely confined to its cliff habitat. The experiments were much too limited to demonstrate the presence or absence of potential var. *Frenchii* in other colonies of this region.

D. Meadia var. *Frenchii* grows just south of the glacial limits in southern Illinois (dots on Map 5). There is also a specimen in the Herbarium of the University of Wisconsin, from Crawford County, Wisconsin, collected on June 27, 1895, by *W. R. Shumann*. The University records show that a student of that name was here in 1895, and came from Prairie du Chien, which is in Crawford County.

The specimen is fragmentary, but the leaf-bases are marked with red and the floral measurements are too large for *D. amethystinum*, the only other species represented in more recent collections from that county. Crawford County is in the Driftless Area, so that the bicentric range of var. *Frenchii* appears to represent a preglacial relic. Its distribution and habitat are very similar to those of *Saxifraga Forbesii* Vasey, as recently discussed and mapped by G. W. Burns.[8]

2. D. AMETHYSTINUM Fassett, Rhodora **33**:224. 1931. *D. Meadia* var. *amethystinum* Fassett, Rhodora **31**:52. 1929. Cliffs along the Susquehanna River, Pennsylvania; eastern West Virginia; "Kentucky, near Ohio River"; cliffs along the Mississippi River in the Driftless Area of Wisconsin, Minnesota, Iowa and Illinois, and at Hannibal, Missouri. Map 6.

This appears to be one of those species which had a fairly general range northeastward before the Pleistocene glaciations, whose occurrence is now limited to localities which escaped glaciation.

D. amethystinum differs from *D. Meadia* in several strong tendencies and in one positive character. The positive difference lies in the wall of the mature capsule, which is 130-340 microns thick in *D. Meadia* and 35-120 microns thick in *D. amethystinum*. Even without microscopic measurement of sections, this difference can usually be seen under the binocular microscope, where the capsule of *D. amethystinum* appears to be of much more delicate texture than

7 Morgan, Sturtevant, Muller & Bridges, The mechanism of Mendelian heredity, p. 39. New York, 1915.

8 Amer. Midl. Nat. **28**:127-160. 1942.

that of *D. Meadia*. The flexible capsule wall of *D. amethystinum* readily gives under a needle point, while that of *D. Meadia* resists pressure until it splits.

The mature capsule of *D. Meadia* is typically ovoid or barrel-shaped and less than 3 times as long as thick (Figs. 3-5), while that of *D. amethystinum* is cylindrical and more than 3 times as long as thick (Figs. 7, 8), but measurement of many capsules shows some overlapping in this character.

In absence of mature capsules the two species are not always easily distinguished. However, the only phase of *D. Meadia* whose range approaches the regions where *D. amethystinum* grows is var. *genuinum* which is usually clearly distinct from it.

In general, the leaves of *D. Meadia* are marked with red at base while those of *D. amethystinum* are not. There are some interesting exceptions to this rule. *D. Meadia* f. *sedens* (Map 2) and *D. Meadia* var. *brachycarpum* f. *pallidum* (Map 4) also lack red pigment in the leaf-bases, but these occur very locally in regions remote from the range of *D. amethystinum*. Close scrutiny of a colony of *D. amethystinum* sometimes yields a few individuals with a faint reddish tinge at base. When pressed, these leaves lose their red coloring (except sometimes for a few short minute red lines) while leaves of *D. Meadia* retain full color when pressed. The difference seems to rest on the presence or absence of an enzyme which oxidizes the red pigment on drying. Professor B. M. Duggar has approached the problem by boiling fresh leaves of each species; those of *D. Meadia* were still deep red at base after 3 hours of boiling although the water was deeply colored by extracted pigment, while the reddest leaves of *D. amethystinum* lost all trace of red pigment when dipped momentarily into warm water.

The difference in pigmentation of leaf-bases is among those mentioned by Dr. Julian Steyermark following his observation of *D. amethystinum* at Hannibal, Missouri.[9] Since Dr. Steyermark is probably the only botanist to have seen the Shooting Star at Hannibal in recent years and to have compared its appearance there with that of *D. Meadia* in other parts of the Middle West, his comments are of value.

Unlike the leaf-bases, the base of the scape is almost always red-streaked in both species.

In Wisconsin, where *D. Meadia* and *D. amethystinum* both grow, although not together, they are distinct in some features which probably do not hold throughout the ranges of each. This is partly because *D. Meadia* is postglacial in Wisconsin whereas *D. amethystinum* is preglacial. Most conspicuous in living plants is the difference in color of flowers. In *D. Meadia* the corolla-lobes grade from pale lilac (very rarely deep lilac) to white; in every colony of *D. amethystinum* the color is almost uniformly deep purple-red, exactly like a solution of potassium permanganate. A few individuals

9 Rhodora **42**:102. 1940.

show a slight dilution of this color, and albinos[10] are very rare. The yellow marking at the base of the corolla is, as in *D. Meadia* and probably every other member of the genus, invariably present, and displays a different pattern in each clone. The floral measurements are smaller in *D. amethystinum* than in *D. Meadia* var. *genuinum,* the only representative of the latter species in Wisconsin: on the expanding flowers the calyx-lobes are 2-5 mm. long in *D. amethystinum* (Fig. 6) and 3-6.5 mm. in *D. Meadia* (Figs. 1, 2); the anthers are 5.0-7.5 mm. long in *D. amethystinum* and 6.5-9.5 mm. in *D. Meadia. D. amethystinum* (Fig. 7) is a slender delicate plant with rarely more than 10 flowers on the scape (18 is the maximum), while *D. Meadia* has many flowers (Fig. 2), sometimes more than 100, on a scape. In the woods *D. Meadia* is less robust and fewer-flowered than it is on the prairies. These differences yield strikingly different aspects in the field. *D. Meadia* appears as a colony of tall coarse many-flowered plants[11] with wide variation in hue; *D. amethystinum* as a colony of small slender few-flowered plants with an essentially uniformly deep color. Moreover, the flowering season of *D. amethystinum* is about two weeks earlier than that of *D. Meadia,* even when the two grow together in a garden, as did those illustrated in Figs. 1-8. Fig. 1 (*D. Meadia*) and Fig. 6 (*D. amethystinum*) were drawn on the same day, and Figs. 2 & 7 are the same plants a few days later.

Outside of the Great Lakes States these distinctions lose some of their force. Many colonies of *D. Meadia,* south of the region of Pleistocene glaciation, consists of uniformly colored[12] individuals, and I have reports of cases where this color is rather deep, from Dr. Steyermark in Missouri and Dr. Hopkins in Oklahoma. *D. Meadia* var. *brachycarpum,* within its limited range (Map 3), approaches *D. amethystinum* in size of plants and of floral parts. *D. Meadia* var. *brachycarpum* f. *pallidum,* in its even more limited range (Map 4), approaches *D. amethystinum* in size of plants and of floral parts, and also in its lack of red pigment in the leaf bases; this form usually has white flowers, but an occasional individual with deeply colored flowers might be distinguished from *D. amethystinum* only by the capsules. No capsules resembling those of *D. amethystinum* have been seen among the many collections from the Ozarks, the Ouachitas, and the Arbuckles, where the form of *D. Meadia* occurs.

There can be no doubt that the Shooting Star in the lower Susquehanna and Schuylkill river valley in eastern Pennsylvania is *D. amethystinum.* In 1935, Dr. G. L. Stebbins, Jr., sent me a plant which he had identified as this, and which had come from a damp sheltered crevice under north-facing sand-

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10 **D. amethystinum** f. **margaritaceum,** n.f., corollae lobis albis.—Wooded, north-facing bluff, McCartney, Wisconsin, May 30, 1930, *Fassett,* no. 10313 (TYPE in Herb. Univ. of Wis.).

11 *D. Meadia* spreads vegetatively by means of buds from the junction of stem and root, forming clones of sometimes a dozen or more rosettes. These clones may often be easily distinguished in the field by their uniformity in color of the corolla-lobes and in the markings at the base of the corolla-tube.

12 We refer here only to pigmentation of corolla-lobes.

stone cliffs along the Susquehanna River, in Union County opposite Northumberland. Dr. E. M. Gress sent plants with the characteristic capsules of *D. amethystinum,* from New Buffalo, Perry County. In May, 1937, Professor E. T. Wherry wrote me as follows: "All normal plants in Lancaster Co. have deeply colored corollas, without any red at base of the leaves, and with thin-walled cylindric capsules. . . . In one large colony there were occasional pure white albinos in the midst of these deep-purple-colored plants. In this colony, too, occurs the curious retrogressive form, with campanulate corolla. . . ."[13] About the same time Mr. Hugh E. Stone wrote me: "Last Saturday . . . west of Lancaster . . . we saw it in fine shape and in perfect young flower. In color it was nearly all a deep purplish-pink (a very little white and some intermediate shades). I saw no suggestion of red color in the leaf-bases. I should say the plants averaged 6 inches to 1 foot high." A month later Mr. Stone sent me mature capsules which he had received from Miss Alice Strickler, who had collected them near Lancaster; these were the narrowly cylindrical and thin-walled capsules of *D. amethystinum.*

In the absence of fruiting specimens it is not possible to state definitely that *D. amethystinum* occurs in West Virginia. The 15 sheets of *Dodecatheon* in the Herbarium of West Virginia University have been loaned by Dr. Earl L. Core, and their characters are presented in Table 1. It may be seen that the individuals without red in the leaf bases have, as a group, smaller floral measurements than those with red in the leaf bases. It thus appears that both *D. Meadia* and *D. amethystinum* grow in the eastern pan-handle of West Virginia, but this should be confirmed by field study and collections of mature capsules. The writer's hesitancy at this point is due largely to his experiences with the genus in Arkansas and Missouri; a large suite of herbarium specimens from these states in the Missouri Botanical Garden were studied, but field studies over a period of several years produced a concept very different from that derived from herbarium sheets alone.

A sheet in the Gray Herbarium, collected by Lesquereux and marked "Kentucky, near Ohio River" seems to be *D. amethystinum.* It was labelled "var. *brevifolium!*" by Gray, but this name appears to belong to a Californian plant; the name "var. *Frenchii,* Vasey" was apparently written by Watson, but the plant is not that variety as here interpreted. The specimen is represented by an interrogation point on Map 6, since the exact location is obscure.

The occurrence of *D. amethystinum* at Hannibal, Missouri, where it was collected many times by Rev. John Davis, and in recent years found in very small numbers by Dr. Julian Steyermark, raises the question of lack of glaciation of the cliffs at that point. The present writer is not competent to make a statement on a matter concerning which geologists are not in complete agreement. Dr. Steyermark has commented on the assemblage of plants at Hannibal which are not known elsewhere in northern Missouri as "evidence that this portion of northeastern Missouri is a 'driftless' area and that it escaped

13 **D. amethystinum** f. **Stricklerae** (Fernald) n. comb. *D. Meadia* f. *Stricklerae* Fernald, Rhodora **39**:320, Pl. 473. 1937.

TABLE 1.—Specimens in the Herbarium of West Virginia University.

	Leaf-bases	Capsule	No. of flowers on each plant	Length of calyx-lobes	Length of anthers
Hanging Rock, Hampshire Co., May 24, 1933, *Wilburt Frye*	not red	none	7	5 mm.	6 mm.
In the woods, Hampshire Co., April 20, 1933, *Anne F. Saunders*	not red	none	4	3.5 mm.	7.5 mm.
North Fork Mt., Grant Co., May 1, 1938, *Mr. & Mrs. H. A. Davis* (3 plants)	not red	a young one, pale and thin-walled	2 2 2	3 mm. 3 mm.	6 mm. 4.5 mm.
Okonoko, Hampshire Co., April 30, 1935, *Wilburt Frye*	not red	none	7	4.5 mm.	7.5 mm.
Deep in woods, on grassy hillside, Hampshire Co., April 29, 1933, *Miriam K. Rinker*	not red	none	4	3 mm.	7 mm.
Above cabins, Grant Co., Monongalia National Forest, April 29, 1939, *Southern Appalachian Botanical Club* (2 plants)	not red	none	7 9	4 mm. 4 mm.	7 mm. 7 mm.
Total, plants without red leaf-bases			2–9 av. 4.9	3–4.5 mm. av. 3.7	4.5–7.5 mm. av. 6.6
Augusta, Hampshire Co., May 15, 1929, *C. N. Fravel* no. 1986. (3 plants)	red	young, red, thin-walled	12 19 10	 4.5 mm.	8 mm. 7 mm. 8 mm.
Terrapin Neck, Jefferson Co., May 6, 1937, *H. Ison Shreve*	red	young, red, thin-walled	24	4 mm.	7.5 mm.
Near Keyser, Mineral Co., April 23, 1939, *Ellsworth Smith* (2 plants)	weak red	none	19 12	 4 mm.	 7.5 mm.
Burlington Campmeeting Grounds, Mineral Co., June 14, 1933, *P. D. Strausburgh.* (Fruits only)	weak red	red, wall 190 microns thick	2		
Same data	red	red, of firm texture	4		
Near Hinton, Summers Co., April 25, 1932, *Weldon Boone*, no. 11	red	none	7	4 mm.	7 mm.
Shaded hillside near R.R., Lavalette, Wayne Co., May 11, 1937, *F. A. Gilbert & Louis Williams*, no. 573	red	none	7	5 mm.	6 mm.
In rich woods, Buffalo Creek, Wayne Co., April 2, 1938, *Lewis Plymale*	trace of red	none	10	6 mm.	7 mm.
New River, Mercer Co., May 3, 1932, *Meade McNeill*	red	none	16	6.5 mm.	8 mm.
Total, plants with red leaf-bases			2–24 av. 11.6	4–6.5 mm. av. 4.9mm.	7–10 mm. av. 7.5mm.

glaciation together with the Ozarks."[14] If the Hannibal area was glaciated, it is the only glaciated area where *D. amethystinum* has been found (Map 6).

The fact that some of the characters by which *D. amethystinum* is separated from *D. Meadia* break down in certain regions will suggest that *D. amethystinum* would be better placed as a variety under *D. Meadia,* as it was originally described. However, the presence of a positive difference in the capsules, in conjunction with strong tendencies in other characters, indicate that they are actually different entities.

D. amethystinum is less closely related to *D. Meadia* than it is to what is called *D. radicatum* Greene, of the Rocky Mountains. But the latter name seems to embrace several elements. It probably came from the "distinct perpendicular tap-root" which Greene described as "at least 1 or 2 inches long," and wrote: "In all the specimens I have been able to examine in American herbaria the remarkable tap-root — a thing so unexpected in the genus — has failed of being preserved. Some part of this organ remains in one of the specimens preserved at Kew, but it is best shown in the British Museum specimen." The type collection is Fendler no. 549; a sheet of this number in the Missouri Botanical Garden appears to be close to *D. amethystinum.* Careful digging of many individuals of the latter species has failed to produce a single tap-root. All our eastern representatives of the genus have a short vertical stem which dies and decays from below as it elongates above; in an occasional individual this disintegration lags sufficiently to produce an axis a few millimeters long and bearing last year's roots toward its base. This might have been interpreted as a tap-root, but the length described by Greene exceeds that observed by the present writer.

The resemblance of many individuals from the Black Hills and the Rocky Mountains to *D. amethystinum* may eventually result in its association with a previously described western species. The confused taxonomy of the genus in the west precludes any such disposition at present.

The filament-tube of *D. amethystinum* varies from 0.5-2.0 mm. in length; in Wisconsin the entire range may be present in a colony, and the collections at the Philadelphia Academy show various filament lengths from eastern Pennsylvania.

D. integrifolium Michx. was described as having "umbellis paucifloris" and was contrasted with *D. Meadia,* with "umbellis multifloris." This suggests that Michaux was describing *D. amethystinum;* in fact the present writer once came to that conclusion and marked a number of sheets in different herbaria with Michaux's name. To settle the identity of *D. integrifolium* an inquiry was sent to the Paris Museum, with characteristic portions of plants to illustrate the characters concerning which questions were asked. The writer is deeply grateful to M. R. Metman and Mr. J. F. Macbride, who happened to be in Paris at the time, for their assistance in this matter. Their report on the type of *D. integrifolium* is that it has leaves marked with red at base, 4

14 Rhodora **42**:102. 1940; see also Rhodora **44**:74. 1942.

or 5 flowers, calyx-lobes about ½ the length of the expanding corolla and of the capsules, anthers 6 mm. long, mature capsule 7-11 mm. long and thick, woody and dark red. This is very clearly *D. Meadia* var. *genuinum*. The characters in shape and margin of leaves, stressed by Michaux, are of no significance (see Fig. 10).

2. The Migrations of D. Meadia

It is now possible to consider something of the geographic and evolutionary significance of the intraspecific variation of *Dodecatheon Media*.

The Arbuckle Mts., the Ouachita Mts., and the Ozarks have stood as uplands since the time of origin of our modern floras. On these ancient uplands *D. Meadia* appears in its greatest complexity. There are three main pairs of characters: robust plants with large floral and fruiting parts (var. *genuinum*) *vs.* slender plants with smaller floral and fruiting parts (var. *brachycarpum*); leaves red at base (var. *genuinum* and var. *brachycarpum*) *vs.* leaves greenish or pallid at base (f. *sedens* and var. *brachycarpum* f. *pallidum*); flowers colored *vs.* flowers pure white. The variation in color acts in a fashion quite different from the other two variables, and will be discussed first.

Throughout most of its range south of the Pleistocene glaciation, each colony of Shooting Star shows a high degree of uniformity as to the pigmentation of corolla-lobes, which are either pure white on nearly or quite all the plants, or else more or less colored on nearly or quite all the plants. The percentage of colored flowers in each colony is shown by the figures[15] on Map 7. It will be observed that south of the limits of glaciation (heavy line on Map 7) and north of the Fall Line (cross-marked line on Map 7), the majority of figures are either 100, signifying all colored, or 0, signifying all white. These are mostly long-established and isolated colonies which have become stabilized for the color factor. That complete stability has not yet been reached in some of the colonies, or that it has been disturbed by some intercolonial breeding, is indicated by the figures in this region, ranging from a small fraction of 1%[16] colored to 20% colored, and in an extreme case 66% colored. The figure of 93%, appearing in central Missouri, signifies, of course, only a small amount of variation, since it is within 7% of being completely colored.

In the regions which were glaciated in Pleistocene time, colonies of Shooting Star have white-flowered plants and plants with colored flowers mixed in any proportion. These colonies, then, are of more recent origin, as should be expected. Colonies in the Driftless Area of Wisconsin are mixed like those of the glaciated regions; *D. Meadia* var. *genuinum* is thus shown to be a recent migrant in that region and not a preglacial relic.

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15 To avoid breaking the continuity of this discussion the data upon which these figures are based will be described in an appendix.

16 Indicated on Map 7 by a broad zero.

Percentages obtained from regions of old drift in Missouri and Indiana show mixed colonies, like those in regions of later glaciation.

Migrations of *D. Meadia* in the Great Lakes States may be considered in terms of centuries or less. It is not primarily a plant of climax formations; it occurs in oak woods as well as on high prairies and low prairies. Its most important habitat a century ago was probably oak openings. Perusal of the notes of the surveyors of south-central Wisconsin, made in the 1830's, list most of the vegetation as "2nd [or 3d] rate timber, oak." Some surveyors noted also: "Undergrowth oak and grass," or "Undergrowth oak, hazle, Red Root, Rosin weed, etc." Such a vegetation is transitional; it represents a prairie being invaded by the forest. Under such transitional conditions *D. Meadia* var. *genuinum*, best adapted to lightly wooded ground, must have been actively migrating.

The mixed colony in northwestern Louisiana (33% on Map 7) is evidently of a more recent origin than are those in the areas of Paleozoic rocks to the north, for it is in a region of Eocene age. Some of the colonies in the vicinity of Shreveport may be on terraces of Quaternary age[17] and so comparable to those on glacial drifts.

Evidence derived from the other types of variation may now be considered. In the highlands from eastern Oklahoma, northern Arkansas and southern Missouri east to central Tennessee and northern Alabama, *Dodecatheon Meadia* is represented by robust plants with large floral parts and fruits (var. *genuinum*), and by slender plants with smaller floral parts and fruits (var. *brachycarpum*). On Map 8 the robust plants are represented by capital letters, and the slender plants by lower-case letters. Each of these varieties has a form with leaves red at base (represented by R and r, respectively, on Map 8), and a form with leaves pallid at base (f. *sedens* and var. *brachycarpum* f. *pallidum*, represented by P and p, respectively). In the region enclosed by the dot-dash line on Map 8, all four of these may occur together in a colony, or any one may be found by itself.

At some time there was a migration, mostly of the robust races, southward to the plateaus of Texas (migrations indicated by arrows and figure 1); this must have been during a period more humid than the present one, perhaps during the advance of one of the Pleistocene glaciers. The endemic var. *Stanfieldii* also occurs in Texas (indicated by S on Map 8). Its character is a long filament-tube, which it may have acquired from some western species then on the Edwards Plateau (suggested on Map 8 by the interrogation point and arrows leading from it), for this character is found now only in several species of the west. Aridity has exterminated *Dodecatheon* on most of the plateaus of Texas, leaving it as a very rare relic "on seepy limestone ledges in the hills of the Edwards Plateau."[18]

Var. *genuinum* (R) is the only element of the species which has spread

17 See Veatch, Geology and underground water resources of northern Louisiana and southern Arkansas. U.S.G.S. Prof. Paper **46**:1-422, plates I-XLIV. 1906.

18 Professor B. C. Tharp, *in litt.*

recently. It has reached the Coastal Plain in Louisiana (arrows, 2) and Arkansas, probably fairly recently, perhaps in Quaternary time. From the highlands of Alabama an offshoot has invaded the Coastal Plain (arrows, 3) and has an almost globular capsule; it is separated as var. *obesum*.

Var. *genuinum* is primarily a plant of prairies and rather open woods. It is the principal element of the species which has spread eastward (arrows, 4); var. *brachycarpum* is also represented eastward by just one collection from Natural Bridge, Virginia. This eastward migration was a long time ago, for each colony which has been investigated is uniform for color (Map 7) just as are those of the Ozarks, the Ouachitas, the Arbuckles and the Balcones Escarpment. At a later period var. *genuinum* migrated into glaciated territory (arrows, 5). The uniformly colored strains of the more southern colonies became mixed again in this process, so that each colony north of the line of the farthest advance of Pleistocene glaciers consists of individuals with white flowers and with colored flowers, mixed in varying proportions.

There is a possibility that migration 4 was at the time of the eastward invasion by the Prairie Peninsula.[19] It would indeed seem logical to suggest that conditions of aridity which opened up Indiana, Illinois, Kentucky, etc., to prairie plants would also have favored the spread of *Dodecatheon Meadia* to Virginia and North Carolina, for that species is a plant of oak openings, a habitat intermediate between the prairie and the forest. But the unform character of its colonies in Kentucky, Tennessee and West Virgnia, would indicate rather a much more ancient, in fact preglacial, time for migration 4.

The events, previous to the migrations just discussed, which resulted in the presence of four types (var. *geniunum*, f. *sedens*, var. *brachycarpum*, and var. *brachycarpum* f. *pallidum*) in the geologically old regions enclosed in the dot-dashed line on Map 8, cannot be readily determined. *Dodecatheon Meadia* has had a long history of migration and local extermination, as is indicated in the next paragraph. Perhaps the variation in the Ozark center came from mutations and gene-flow throughout the group as it existed in that region. On the other hand, *D. Meadia* may have existed in several isolated centers and by subsequent reëxpansion have evolved this complex population. Possibly, the eastern plants represent such a very ancient center rather than a migration from the Ozark center.

A preglacial or interglacial migration northward, at a time much earlier than that of var. *genuinum*, is indicated by the range of var. *Frenchii* (dots on Map 5, and F on Map 8). This variety is known only from southern Illinois, south of the region of Pleistocene glaciation, and from the Driftless Area in Wisconsin. It once had, presumably, a distribution northward from the Ozark center, was unable to migrate following glaciation, and now occurs as a relic in the parts of its former range which escaped glaciation.

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19 Cf. Transeau, in Ecology **16**:435. 1935.

Summary

There are two species of *Dodecatheon* in eastern North America. *D. amethystinum* shows very little variation, exists only in unglaciated regions, and appears to have had a wider range in preglacial time. *D. Meadia* consists, in the geologically ancient regions of the midsouth, of numerous races, all of which may grow together. The more recently vegetated lands, *i.e.*, the Coastal Plain and the areas of Pleistocene glaciation, have usually but one *Dodecatheon*, belonging to a race present in the ancient regions and apparently the only element capable of extensive migration.

Certain regions will therefore have characteristic populations of Shooting Star, as follows:

1. Pleistocene drift. *D. Meadia* var. *genuinum*, a postglacial migrant from the south.

2. The Driftless Area of Wisconsin and regions immediately south of Pleistocene glaciation. *D. amethystinum*, apparently a species with a preglacial distribution in the northern states, now a relic. *D. Meadia* var. *Frenchii*, in the Driftless Area and extreme southern Illinois, seeming to be a relic of a preglacial expansion of *D. Meadia*. *D. Meadia* var. *genuinum*, a postglacial migrant from farther south.

3. The Cumberland, Ozark, Ouachita and Arbuckle plateau regions: A complex assemblage of conservative elements (*D. Meadia* f. *sedens*, var. *brachycarpum* & *f. pallidum*), and a more aggressive element (*D. Meadia* var. *genuinum*).

4. The Appalachian Mountains. *D. Meadia* var. *genuinum*, rare and possibly very ancient in the region but more likely present as a migrant at some undetermined period from region 3. *D. Meadia* var. *brachycarpum* even more rare. In West Virginia and eastern Pennsylvania, the northern limits of the unglaciated part, occur *D. amethystinum*, as a relic of a pre-Pleistocene range.

5. The Balcones Escarpment. *D. Meadia* var. *genuinum*, f. *sedens*, var. *brachycarpum*, and var. *Standfieldii*. The first three were probably migrants from the Ozark center to the Edwards Plateau during a humid period; they are now extinct on the plateau but remain on its margin where water seeps from strata of limestone. The fourth has characters suggesting an ancient fusion with a Rocky Mountain element which may have been on the Edwards Plateau at some ancient time.

6. The Coastal Plain of Arkansas and Louisiana. *D. Meadia* var. *genuinum*, as a migrant from the Ozark center, perhaps as recently as Quaternary time.

7. The Coastal Plain of Alabama. The little-known *D. Meadia* var. *obesum*.

APPENDIX I.

Sources of data from which percentages on Map 7 were derived.

WISCONSIN.

Between Mazomanie and Sauk City, on a bluff of the Wisconsin River, with a prairie flora. Count by J. T. Curtis, Harold Roberts, and the writer, on May 13, 1941. 47 plants with colored flowers, 31 with white flowers: recorded on the map as 60%.

Between Cross Plains and Middleton, on prairie relics bordering the railroad tracks. In this length of 11.3 miles, color counts were made in 19 patches by the writer and his students, mostly on class field trips, in May, 1941. The percentage of colored individuals ranged from 25 to 65. The total counts were, 1246 plants with colored flowers, 1356 with white flowers, or 48% colored.

Near Waunakee, on a prairie hillside, May, 1937, John Catenhusen. 90 colored, 100 white, or 47% colored.

Near Mineral Point, in a moist prairie, May 18, 1940, by the writer. 61 colored, 28 white, or 69% colored.

Sugar River Forest Preserve, Rock County, June 4, 1937, John T. Curtis. About 150 plants present, estimated half with colored flowers, and recorded on the map as 50%.

Waukesha, June 4, 1937, John T. Curtis. About 500 plants present, of which 200 were counted and found to have 91% with colored flowers.

Large prairie-savannah near Scuppernong Marsh, Waukesha County, June 4, 1937, John T. Curtis. Estimated 10,000 plants, of which 250 were counted and found to have 9.6% with colored flowers. Recorded on the map as 10%

MISSOURI.

Northern side of a high limestone bluff, overlooking Silver Creel Fork, 10 miles north of Columbia, in glaciated territory, May, 1940, William B. Drew. Dr. Drew wrote me as follows: "Out of a total of 104 plants studied, 20 individuals bore perfectly white flowers with no trace whatever of a pink flush. Another 16 plants bore flowers which may be said to be a very definite pink. The remainder, or some 68 plants, bore flowers ranging in shade from nearly white to nearly definitely pink. Most of this latter and larger group were noticeably pinkish and could not be confused with the 'alabaster' white of the 20 pure white plants." Recorded as 81% colored plants.

South of Columbia, presumably in the Nebraskan drift, May 14, 1940, William B. Drew. Deep pink, 15 plants; intermediate between pure white and deep pink, 3 plants; pure white, 3 plants. Recorded as 86% colored.

Gray Summit: Dr. Edgar Anderson wrote me as follows on May 24, 1940: "I have not seen a single white plant at Gray Summit nor do I remember ever having seen one in previous years." Recorded as 100% colored.

Near Dry Sac River, Springfield, April 18, 1938, Mrs. Edith Seymour Jones. 80 plants with colored flowers, 6 with white flowers. Recorded as 93% colored.

Prairie relic along railroad, Aurora, April 23, 1938, by the writer. 1 plant with colored flowers, about 50 with white flowers. Recorded as 2% colored.

Fairy Cave, Reed Springs, April, 1938, Mrs. Edith Seymour Jones. Observed that all plants had white flowers. Recorded as 0 colored.

Starland, Perry County, April 21, 1938, Julian A. Steyermark. Dr. Steyermark made the following notes: "Pure white, 42. White mixed with pale lilac pink (very pale color, just a shade off the white), 75. Slightly rose (the darkest type), 7." Recorded as 66% colored.

ARKANSAS.

Beaver, northwest of Eureka Springs, May, 1940, E. L. Nielsen. 200 to 300 plants, all white-flowered. Recorded as 0% colored.

Glade near Green Forest, April 18, 1940, D. M. Moore and the writer. Several hundred plants, one with very faintly pink flowers, the rest pure white. Recorded on the map by a broad zero, representing a figure between 0 and 1%.

Cliff and wooded hillside, Pettigrew, April 17, 1940, D. M. Moore and the writer. Several hundred plants, all with white flowers. Recorded as 0% colored.

Wooded cliff, Hilltop, April 18, 1940, D. M. Moore and the writer. About 100 plants, all with white flowers. Recorded as 0% colored.

On May 28, 1940, Dr. Moore sent me descriptions of the following six colonies. His figures include not only color of flowers, but presence or absence of red coloring at the base of leaves. Elsewhere I have made the statement that in this region colonies can be found with leaves all red at base, or with no leaves red at base, or with the two types mixed in any proportions. Dr. Moore's figures serve to demonstrate that there is no correlation between the two sets of characters.

1. Eight miles east of Siloam Springs. 21 plants, all with white flowers; 12 had leaves green at base, 9 had them red at base. Recorded as 0% colored flowers.

2. Near the first colony. 46 plants with white flowers; 18 of these had leaves green at base, 28 had them red at base. 5 plants with lavender flowers; 1 of these had leaves green at base, 4 had them red at base. Recorded as 10% colored flowers.

3. Four miles west of Siloam Springs. All plants with leaves red at base; 50 with white flowers, 5 with lavender flowers. Recorded as 9% colored flowers.

4. Monte Ne. 32 plants with white flowers; 30 of them had leaves green at base, 2 had leaves red at base. 8 plants with lavender flowers; 6 of them had leaves green at base, 2 had leaves red at base. Recorded as 20% colored flowers.

5. Monte Ne. Several dozen plants, all with white flowers, and leaves all green at base. Since northwestern Arkansas is crowded with figures on Map 7, the zero representing this colony is omitted.

6. Monte Ne. A large number of plants, all with colored flowers and all with leaves green at base. Recorded as 100% colored flowers.

Wooded cliffs, Durham, April 19, 1937, by the writer. Several thousand plants, of which but 2 had faintly colored corollas. Recorded on the map by a broad zero, representing a figure between 0 and 1%.

Low prairie, Buell, April 19, 1938, V. M. Watts and the writer. About 50 plants, all with white flowers. Recorded as 0% colored flowers.

Along a stream just north of Rich Mountain, Mena, April 22, 1937, V. M. Watts and the writer. From this colony were collected the plants represented by the dash-dot line on Graph 1. Many plants, all with white flowers. Recorded as 0% colored flowers.

Along a stream north of Buck Knob, Scott County, April 19, 1939, V. M. Watts and the writer. About 200 plants, all with white flowers. Recorded as 0% colored.

OKLAHOMA

Professor Milton Hopkins has told me, in conversation, that in the Arbuckle Mountains each colony observed by him has been either all white-flowered, or else composed entirely of plants with colored flowers. Recorded as a 100 and a 0 placed on the map in that part of Oklahoma.

Sapulpa, April 23, 1941, L. H. Shinners. About 30 plants, all with colored flowers.

LOUISIANA.

Near Shreveport, a colony which was once large has been observed for some years by Mrs. Ruth M. Dormon. She tells me that when she first knew it, about a third of the plants had colored flowers. Recorded as 33% colored.

TEXAS.

Professor B. C. Tharp has told me, in conversation, that he has seen a total of perhaps a hundred plants of *Dodecatheon*, which is very rare in Texas, and never seen one with colored flowers. Recorded as 0% colored.

INDIANA.

McCormicks Creek State Park, near Spencer, May 24, 1940, count by L. H. Shinners, F. W. Stearns and the writer. 63 with colored flowers, 237 with white flowers. Recorded as 21% colored.

OHIO.

Lynx, Adams County, May 25, 1940, Professor E. Lucy Braun. 5 with colored flowers, 139 with white flowers. Recorded as 3% colored.

WEST VIRGINIA.

Dr. E. L. Core wrote me on May 9, 1937, as follows: "I have never observed white flowers of *Dodecatheon* in West Virginia. Sometimes, however, they seem to be more deeply colored than usual." Recorded as 100%, in the vicinity of Morgantown.

Huntington, May 22, 1937, Dr. Frank A. Gilbert. In a colony of 96 plants, 6 showed slight coloring. Recorded as 6% colored.

Huntington, May 22, 1937, Dr. Frank A. Gilbert. In a colony of 12 plants, none showed any coloring. Recorded as 0% colored.

KENTUCKY.

Elk Lick Falls, 14 miles east of Lexington, May 4, 1938, Prof. Frank T. McFarland. Hundreds of plants with white flowers, 2 colored. Recorded on the map by a broad zero, representing a figure between 0 and 1%.

Balltown, Nelson County, May 18, 1940, Prof. E. Lucy Braun. Many plants with white flowers, none with colored flowers. Recorded as 0% colored.

Cave Ridge, Metcalf County, May 18, 1940, Prof. R. Lucy Braun. Many plants with white flowers, none with colored flowers. Recorded as 0% colored.

TENNESSEE.

On May 22, 1937, the late Prof. H. M. Jennison wrote me: "I have never collected one with colored petals around here." Recorded by a zero in the region of Knoxville.

Dr. H. K. Svenson writes, Journ. Tenn. Acad. Sci. 16: 152. 1941, "All the plants seen by me in Middle Tennessee are white-flowered except for a single stand in prairie soil along the railroad east of Tullahoma (no. 9967), in which the flowers are lavender." This is recorded by a 100 on the map in the region of Tullahoma.

On May 18, 1937, Prof. Eleanor McGilliard wrote me: "All I have ever seen has had white flowers." Recorded as a zero, in the region of Chattanooga.

APPENDIX II.

On Map 9 have been placed figures showing the percentage of individuals with colored flowers in a series of 19 colonies of *Dodecatheon Meadia*, between Black Earth and Middleton, Wisconsin. These counts were taken as a test of the validity of the percentages shown on Map 7.

Two facts are demonstrated. First, the percentages may show a wide range of variation in one region. On Map 7, therefore, there is no immediate significance in the face that there is 21 in southern Indiana and an 81 in northern Missouri. Of course, if a series of many counts in each of these regions should show intercolonial uniformity, as contrasted with the variation in colonies found in Wisconsin, a new line of evidence would perhaps be opened.

Second, none of the 19 counts in Wisconsin approach uniformity for the color factor. This indicates that on Map 7 a figure or 100 or of zero is significant, as opposed to one between 20 and 80.

If there is a correlation between any environmental factor and the proportions of colored flowers, as presented on Map 9, it is not obvious to the present writer. Black Earth Creek, rising a few miles west of Middleton, flows westward through a narrow valley toward the Wisconsin River. At one time[20] glacial drainage flowed westward

[20] These details are mostly from Alden, the Quaternary geology of southeastern Wisconsin. U.S.G.S., Prof. Paper 106. 1918.

from Middleton, but now the plain just north of Middleton, a former lake bed, drains eastward. The ice of the Third Wisconsin Glacier, moving from the east, came as far west as Cross Plains. The part of the valley west of Cross Plains, margined by steep hills, is partly filled by outwash. The part of the valley east of Cross Plains, having been glaciated, has lower and more gradual walls, and is filled with morannic material which has been partly reworked by glacial streams.

The vegetation is represented as it was found a century ago by the surveyors who laid out the section lines.[21] The outwash west of Cross Plains was mostly low prairie, with a little marsh. Most of the valley east of Cross Plains was, like the surrounding hills, covered with scattered oaks ("oak opening"), often with an undergrowth of grass. The lake bed north of Middleton wash marsh toward the center with a rim of low prairie.

The lake bed is now under cultivation and the hills are heavily pastured. Original vegetation is found only along the railroad which runs through the valley. Shooting Stars were probably once common over the whole area but now persist only along the railroad, and it is there that color counts have been made.

The percentages of plants with colored flowers show in general an increase from east to west in this valley. This change or progression may represent a condition similar to those observed in *Rubus odoratus*[22] and in *Diervilla Lonicera*.[23] On the other hand, it has been suggested that the stations nearest Madison (6 miles east of Middleton) and therefore most subject to wild-flower picking, show the smallest proportions of colored individuals. The "nature lovers" have not been polled on color preference.

Color Counts of *Dodecatheon Meadia* from Black Earth to Middleton, Wisconsin

Distance east of previous station	Number with colored flowers	Number with white flowers	Percentage with colored flowers
	14	10	58
1.4 mi.	61	36	63
1.1	88	47	65
1.1	143	87	62
2.2	41	91	31
0.6	69	42	62
0.2	75	73	51
0.7	82	65	56
0.3	72	43	63
0.6	77	73	51
0.2	50	98	34
0.2	100	74	58
0.4	62	67	48
0.2	87	81	52
0.3	59	108	35
0.2	48	108	31
0.3	47	68	41
0.5	42	94	31
0.8	29	89	25

21 Original notes on file at the Land Office, Wisconsin State Capitol.
22 Ann. Missouri Bot. Gard. **28**(3):299-374. 1941.
23 Bull. Torrey Bot. Club **69**(4):317-322. 1942.

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The Tofieldia glutinosa Complex of Western North America

C. Leo Hitchcock

Prior to 1879 the false asphodels of Oregon and Washington were considered to be the same as *T. glutinosa* of the Atlantic Coast. In that year Watson (Proc. Am. Acad. 14:283. 1879) separated part of the plants of the western United States as a new species, *T. occidentalis* Watson. However, he believed that *T. glutinosa* was to be found in Western North America as far south as Oregon. The basis on which he established his species can be seen in the following table which includes the characters for *occidentalis* and those contrasting characters of *glutinosa* which Watson mentioned.

	occidentalis	*glutinosa*
stem	1-2 ft. tall	½-1½ ft. tall
pubescence	viscid-pubescent	glutinous-pubescent
leaves	not mentioned	2-3 lines broad
racemes	an inch long	short (½-2 inches)
pedicels	becoming 3-5 lines long	2 lines long in fruit
involucre	3-lobed nearly to middle	scarcely lobed
perianth	2½-3 lines long	length not mentioned
capsule	thin, obovate, 3-4 lines long, long-beaked	thin and light-colored, oblong, 2½ lines long, short-beaked
seeds	with loose white spongy testa, a slender tail at the outer end	minute, with close brownish testa, a contorted tail at each end
range	N. California to Washingtotn Territory	Alaska to Oregon, Wyoming, and Canada (to Newbrunswick), and in the Alleghenies to N. Carolina

From this comparison it can be seen that Watson was establishing his species on the basis that it differed from *glutinosa* in having longer pedicels, a more deeply lobed involucre, a longer-beaked capsule, and a different type of seed-coat.

Rydberg (Bull. Torr. Bot. Club 27:528. 1900) proposed a third species, including most of those western plants occurring in the triangle formed between Saskatchewan, Wyoming, and Alaska, calling it *T. intermedia*. Of *T. glutinosa* he said "it . . . has an elongated raceme, longer pedicels, and oblong subequal sepals and petals about 4 mm. long." The three species *glutinosa, occidentalis,* and *intermedia* assertedly differed as follows:

	intermedia	*occidentalis*	*glutinosa*
stem	1.5-3 dm. tall, viscid-pubescent above	not mentioned	not mentioned
raceme	short, dense, 1-2 cm. long	not mentioned	"elongated"
pedicels	very short, in fruit 1-4 mm. long	longer than in *glutinosa*	longer than in *intermedia*

involucre	connate ca. 2/3 length	less connate than in *glutinosa*	not mentioned
sepals	4-5 mm. long, petals somewhat narrower and longer	narrower than in *glutinosa*	oblong, subequal, sepals and petals ca. 4 mm. long
capsules	ovoid, ca. 5 mm. long	8 mm. long	not mentioned
seeds	appendaged	not mentioned	not mentioned
beak	ca. 1 mm. long, spreading	longer, ascending	not mentioned

It would seem then, that Rydberg believed his species to be unique in having a short dense raceme, short pedicels, connate involucre, and short spreading beak. Whereas it can be seen from the above comparison that *intermedia* differs from *occidentalis*, there is little to convince one that it is distinct from *glutinosa*. It will be noticed that the nature of the testa of the seeds was not mentioned even though Watson had called attention to the "loose white spongy testa" of *occidentalis*. Rydberg cited one collection of *occidentalis* from the Rocky Mountains (Avalanche Mt., B. C., 1890, *J. M. Macoun*), but in his Flora of the Rocky Mountains (p. 147. 1922) he gave the range of *T. intermedia* as "Sask.;—Wyo.—Calif.—Alaska" and that of *occidentalis* as "B.C.—Calif.—Ida." In the latter work the two species were keyed apart in the following way:

Bractlets broadly triangular, connate 2/3 their length	*T. intermedia*
Bractlets lanceolate triangular, connate their length or less	*T. occidentalis*

Since *glutinosa* was not mentioned it seems obvious that Rydberg did not believe that that species occurred in Western North America. Thus, although those plants from Wyoming, Montana, and Idaho were all included in *glutinosa* by Watson, they were placed in *intermedia* and *occidentalis* by Rydberg.

Abrams, Ill. Fl. Pac. States 1:372. 1923, included all Pacific Coast false asphodels in *T. occidentalis*, giving the range of that species as 'Southern Alaska to Mendocino County, and the Southern Sierra Nevada, California.' Peck, Man. Pl. Oreg. 189. 1941, reduced *T. intermedia* to a variety under *occidentalis* on the ground that it "is lower and less glandular, usually with relatively broader and shorter leaves; filaments averaging more slender and the anthers smaller." The range of the variety was given as "Cascade Mts. to Alaska and California," whereas that of the species (*T. occidentalis*) was "Lane and Douglas Cos., Oregon, and eastward through the Coast, Siskiyou, and Cascade Mts., at middle altitudes, to Alaska and California."

In attempting to identify a few specimens of *Tofieldia* collected in Washington the writer noted the lack of agreement in the taxonomic treatment of our western plants of the genus and subsequently attempted to evaluate the taxonomic status as well as to ascertain the geographic distribution of these various "species" of the genus. Besides the collection of the University of Washington (W), material has been studied from the herbaria of the California Academy of Sciences (CA), University of California (C), the Gray

Herbarium (G), and the New York Botanical Garden (NY). To the curators of these herbaria I am indebted and hereby express my gratitude.

T. GLUTINOSA (Michx.) Pers. Syn. 1:399. 1805.

Stems 1-5 (8) dm. tall, glabrous or sparsely glandular-pubescent below to densely glandular-pubescent above, with 1-3 sheathing leaves at base, otherwise leafless or with a small bract below inflorescence; the inflorescence itself very glandular-pubescent with hairs 1-4 times as long as thick, congested to elongate, 1-7 cm. long, the flowers mostly in 3's, on pedicels 1-6 (10) mm. long, rarely, the inflorescence semi-paniculate; bractlets below each flower* 3, 1-2 mm. long, connate (1/2) 2/3 - 4/5 their length, completely united and scarcely at all lobed, or (rarely) split to base in 1 or more places; flowers partially concealed in bracts or (especially after anthesis) exserted 1-2 mm. from them, white to creamy-white or greenish-white; sepals rather oblong-obovate, (2.5) 3-4.5 (5.5) mm. long; petals narrower and more elongate (3) 3.5-5.5 (6.5) mm. long; stamens equal to or slightly longer than perianth; capsules 4-8 mm. long, membranous, often purplish, tipped by persistent straight or curved styles 0.6-2 (2.5) mm. long; seeds surrounded by spongy and more or less inflated testa, the rest of seed free within, or testa not inflated but grown to rest of seed, the funiculus often persistent and forming a short curled "appendage" at base, at the opposite end the testa usually prolonged into a contorted appendage which is often at least as long as the body of the seed.

Range: wet places from the Atlantic Coast to southern Alaska, south to Wyoming, Idaho, and California.

Differing from *T. racemosa* chiefly in that the perianth and capsule do not become hardened as they mature.

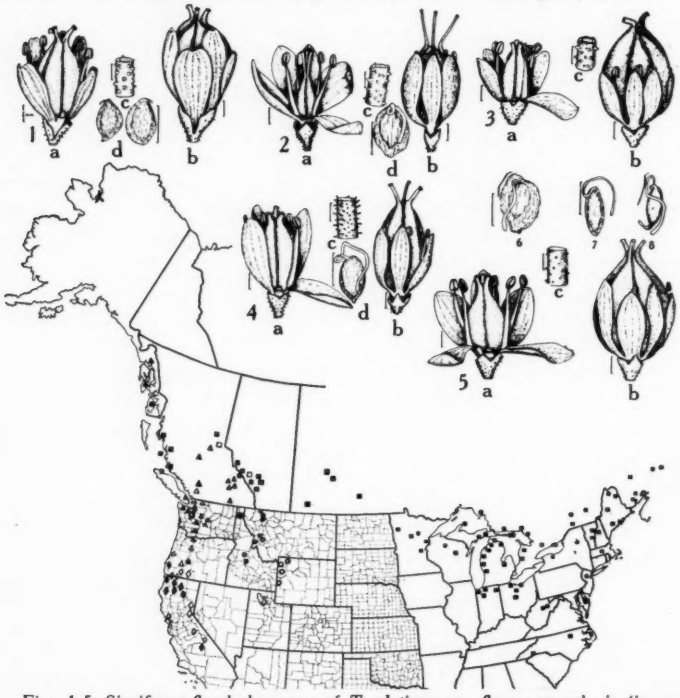
As mentioned previously, Watson separated much of the western material from the eastern plants, calling it *T. occidentalis*. Most of the differences between the two entities which he stressed appear to be definite enough, except that there is no essential difference in their involucres. The differences in the testa of the seeds is especially striking. Plants growing in the region from southern British Columbia eastward to the Selkirk Mountains, and southward to California have seeds with a very spongy whitish testa, whereas those from the northern Rocky Mountains eastward to the Atlantic Coast, as well as most of those from the northern British Columbia and Alaska, have seeds with a testa that is appressed, rather than loose, the seeds therefore being definitely brownish in color. Whether or not the testa is inflated, however, appendages usually are present at each end of the seed, the shorter of the two being the funiculus. The funiculus may or may not adhere to the seed.

However, all material with seeds which have an inflated testa is not uniform. Plants from northern Oregon, Washington, and British Columbia do not have nearly such long styles as do those from California and southern Oregon. Specimens from Montana differ from those of either Washington or

* Often referred to as an involucre.

California in that they have longer and more slender glandular hairs on the peduncles and branches of the inflorescence. Plants from Priest Lake, Idaho, are unique in that they have retuse perianth lobes and very short appendages to the seeds.

There are, then, five fairly well marked entities in the complex, each of which has a rather well defined geographic range. Population one, from California and southern Oregon, includes the type of *T. occidentalis*. It is peculiar because of the long styles and loose testa. Population two, also with a loose testa, but with short styles and short glandular hairs on the inflorescence, is the phase of the plant that occupies the region north of the range of *T. occidentalis*. The Priest Lake, Idaho, plants represent a third group which is a



Figs. 1-5. Significant floral characters of *T. glutinosa*. a—flower at anthesis (in most cases); b—mature fruit; c—a portion of stem immediately below inflorescence; d—seed. Fig. 1—ssp. *absona;* Fig. 2—ssp. *occidentalis;* Fig. 3—ssp. typica; Fig. 4—ssp. *montana;* Fig. 5.—ssp. *brevistyla*. Scale as indicated on each unit—1 mm.).

Fig. 6, 8, 7. Seeds of ssp. *brevistyla*, ssp. *typica*, and of suspected hybrid between the two.

Distribution map of the species. Squares represent collections of ssp. *typica;* circles —ssp. *montana;* triangles—ssp. *brevistyla;* diamonds—ssp. *occidentalis;* cross-in-square—ssp. *absona*. Solid symbols represent collections that had mature seeds.

local variant of population two. Population four is to be found chiefly in Montana and Wyoming; it is characterized by a loose testa, short style, and long glandular hairs in the inflorescence. The fifth population is the phase originally described as *T. glutinosa*. It is eastern and far northern in range and is very similar to population two, except that the seeds have a tight-fitting testa.

To ascertain just what other differences in floral character there might be between the five phases, a considerable number of flowers at the same stage of development were studied from each group. There was no significant variation detectable in any floral character except for the difference in the style length of the California plants. There is a slight difference in length of sepals, petals, and pedicels, the plants from the Pacific Coast (populations one and two) being slightly larger-flowered. The length of the inflorescence, whether measured at anthesis or at time of fruit, shows no significant constant variation.

There are three possible ways in which these five closely related entities might be treated taxonomically.

1. Each might be accorded the rank of a species. Since each can be recognized without too much difficulty, this method of treatment would doubtless appeal to some workers. However, the five plants are all much more similar to one another than they are to any other of the species of the genus. The fact that they have for so long been confused with one another would indicate that, with casual examination, they appear to belong to one and the same entity. If they are to be maintained as separate species, the specific lines separating them would have to be drawn on questionably significant distinctions.

2. Recognize two species, *T. occidentalis* (to include population 1) and *T. glutinosa* (population 5). It would then be a question of the disposition of the other entities. Population two has the same type of seeds as *occidentalis* and would seem therefore to belong with that species, perhaps as a subspecies. In all particulars other than that of seed coats, however, the plant is more similar to *glutinosa*. In such a scheme population four would probably be placed under *glutinosa*, since it has flowers identical with that plant, but it has an inflated testa, a characteristic unlike *glutinosa*, but like *occidentalis*.

3. Assign the five entities to subspecific rank under the one species *T. glutinosa*. If this be done, *T. glutinosa* is interpreted to be a widely distributed species with five distinct populations, each occupying a separate, rather natural geographic area. There is but little overlapping in the ranges of the five entities, but as might be expected, intergrades between the different populations occur where their ranges coincide. The five populations fit the writer's conception of subspecies, and therefore are being treated under that category.

KEY TO SUBSPECIES OF TOFIELDIA GLUTINOSA

Testa of seeds whitish but rather closely appressed to rest of seed, the seeds, therefore, brownish in appearance, nearly ellipsoid; sepals averaging ca. 3.2 mm. long; pedicels of fruits mostly less than 5 mm. long; that portion of stem just below the inflorescence with glandular hairs 1-2 times as long as thick.....*T. glutinosa* ssp. *typica*

Testa of seeds loose, papery, much inflated, the seeds thus appearing whitish; sepals

averaging slightly over 3.2 mm. long; pedicels of fruits often over 5 mm. long; pubescence of stem often longer than in ssp. typ.

Styles averaging nearly 2 (1.2-2.5) mm. long, slender, straight or nearly so; sepals averaging ca. 4 mm. long; petals averaging ca. 4.5 mm. long; capsules mostly 6-9 mm. long ..... *T. glutinosa* ssp. *occidentalis*

Styles averaging ca 1 (0.5-1.5) mm. long; sepals and petals averaging slightly less than 4 mm. long; capsules mostly not over 7 mm. long.

Pubescence of upper part of peduncles consisting of hairs that are only 1-2 times as long as broad, tapered like a haycock; sepals averaging ca. 3.8 mm. long; petals averaging ca. 4.2. mm. long.

Appendages of seeds usually at least half as long as seed; petals and sepals seldom retuse; involucral bracts usually united 1/2-2/3 their length..... ..... *T. glutinosa* ssp. *brevistyla*

Appendages of seeds lacking or much less than 1/2 as long as body of seed; petals and sepals usually retuse; involucral bracts mostly free to base in one or more places ..... *T. glutinosa* ssp. *absona*

Pubescence of upper part of peduncles consisting of hairs 3-4 times as long as thick, nearly uniform in thickness throughout their length; sepals averaging ca. 3.5 mm., the petals ca. 4 mm., in length..... *T. glutinosa* ssp. *montana*

a. T. glutinosa (Michx.) Pers. ssp. typica

T. glutinosa (Michx.) Pers. l. c.

Narthecium glutinosum Michx. Fl. Bor. Amer. **1**:210. 1803.

Tofieldia intermedia Rydberg, Bull. Torr. Bot. Club **27**:528. 1900, in part only, but probably including type.

Stems 1-4 (5) dm. tall, glabrous or sparsely glandular below to thickly glandular-pubescent near inflorescence, the hairs 1-2 (3) times as long as thick, tapered from base to tip; inflorescence 1-4 (0.5-6.5) cm. long at anthesis, the pedicels 1-5 mm. long, but in fruit the inflorescence elongated to as much as 8 cm. and the pedicels to as much as 1 cm.; bractlets below each flower connate about ¾ their length, but occasionally split to base in one or two places, or entirely connate and scarcely at all lobed, the flower partially concealed by bractlets or exserted as much as 2 mm.; flowers creamy-white; sepals oblong-obovate, 2.5-4 (averaging ca. 3.2) mm. long, 3 (5)-veined; petals narrower and somewhat more acute, 3-5 (averaging ca. 3.6) mm. long; capsules mostly 5-6 mm. long, membranous, sometimes purplish, the carpels usually united as far as the base of the styles; styles 0.4-1.2 mm. long, usually recurved, mostly thick at base and narrowed gradually to the scarcely enlarged stigmas; seeds brownish in color, surrounded by close-fitting testa, the testa spongy and free at ends only; funiculus, in whole or part, forming a short curved appendage, the opposite end always with a twisted curved appendage often as long as body of seed.

Type: unknown.

Range: Newfoundland to North Carolina and westward to Minnesota, northwestward through Manitoba, Saskatchewan, and Alberta to coastal northern British Columbia and southern Alaska.

Representative of material seen (Note—the starred (*) collections are ones which

have seeds mature enough to show the true nature of the testa.): Without definite locality —Rocky Mts., *Drummond* (G) and *Lyall* in 1861 (G). ALASKA—Sitka, *Eastwood* in 1914, with some doubt (CA) and *Haley* in 1926, the seeds a little immature, but apparently with tight-fitting testa (CA); Craig, *J. P. Anderson 2669** (Anderson Herbarium at Iowa State College).

BRITISH COLUMBIA—without further locality, *Lloyd* in 1892* (NY); Cape Scott, Vancouver Is., *McCabe 3144** (C); Calvert Is., Safety Cove, *McCabe 1772**, approaching ssp. *brevistyla* (C); s. of Kwakshua, Calvert Is., *McCabe 3064** (C); Le Roy Lake, Smith Inlet, *McCabe 1821** (C); Smith Is., Bardwell Group, *McCabe 3170** (C); Goose Is., *McCabe 7137** (C); Banks Is., *McCabe 7365** (C); Graham Reach, n. of Swanson Bay, *McCabe 3207**, intermediate with ssp. *brevistyla* (C); Kinbasket Lake, *McCabe 5302** (C); 25 mi. no. of Barkerville, *McCabe 1* and *1A*, with considerable doubt since seeds very immature (NY) and *McCabe 300*, also immature (C); Emerald Lake, Yoho Nat. Park, *Hitchcock & Martin 7721** (NY), *Shaw 100*, annotated as *T. intermedia* by Rydberg, but too immature to be identified with certainty (G, NY), and *Brown 328* (NY); Kicking Horse Valley, near Field, *Brown 208*, too immature (CA); Carbon R., 4 mi. above the Peace, *Raup & Abbe 4297** (NY).

ALBERTA—headwaters of Saskatchewan and Athabasca R., *Brown 1364* (G, NY) and *Brown 1467** (G); Banff, *Barber 285* (G), *Canby 294** (G), *Farr* in 1905 (G), *Johnson 1188** (NY), *Macoun* in 1891 (G), *Malte & Watson 779* (G), *McCalla*, annotated by Rydberg as *T. intermedia*, but definitely ssp. *typica* (NY), *Olson* in 1909 (G), and *Van Brunt 93** (NY); Morley Dist., *Brinkman 3465* (NY); Bow River at Calgary, *Macoun 216** (G); Prince Is., near Calgary, *Moodie 68*, definitely this entity but annotated as *T. intermedia* by Rydberg (NY); Elbow R. Valley near Calgary, *Macoun 25102* (NY) and *Moodie 1065* (NY); Fortress Pass, *Ostheimer 64* (G); 5 mi. sw of Nordigg, *Malte & Watson 1386** (G). SASKATCHEWAN—Prince Albert, *Fraser 12* (NY), *Macoun 13861* (G), and *Johnson 1349** (NY); Saskatchewan Plains, *Macoun 1832* (G).

All of the material from east of Montana belongs to this subspecies, the following collections being typical: Stony Mt., Manitoba, *Macoun 13860** (G); Little Eagle Harbor, Lake Huron, Ontario, *Macoun 54110** (G, NY); Cap a l'Ours, Anticosti Is., Quebec, *M.-Victorin 4205** (C, G); Grand Falls, New Brunswick, *Boott* in 1873* (G); n. shore of Notre Dame Bay, New Foundland, *Fernald & Wiegand 5173** (G); Marquette Is., Michigan, *Manning* in 1913* (G); Melvin, Polk Co., Minn., *Stevens 432* (G); Washington Is., Door Co., Wisconsin, *Schuette* in 1896 (NY); near Chicago, Illinois, *Churchill* in 1893* (G); Edgemoor, Indiana, *Lansing 2610** (G); Cedar Swamp, Champaigne Co., Ohio, *Werner 157** (NY); Cheat Bridge, Randolph Co., W. Virginia, *Hutton 105** (NY); Devil's Court House, North Carolina, *Gray* in 1843 (NY); Sumner's Falls, Connecticut, *Eggleston 2808** (NY); Plainfield, New Hampshire, *Eggleston* in 1893 (NY); West Woodstock, Vermont, *Kittredge** (NY); Caribou Bay, Crystal, Maine, *Fernald* in 1901* (C, CA, G).

Since the species as a whole is found only in bogs or swampy ground, mostly under alpine, subalpine, or subarctic conditions, it seems obvious that it is one which has originated in the arctic and spread southward in glacial time. Ssp. *typica*, transcontinental in range, is apparently the prototype of the entity, the other subspecies having differentiated in the mountainous regions of the west (see distribution map).

Plants belonging to ssp. *typica* are easily separated from individuals of the other subspecies because of the close-fitting testa, and because of the more conspicuous appendages of the seeds. In only one case has a plant with seeds of this nature been found from a region where ssp. *typica* does not regularly occur. Although the seeds of ssp. *montana* also have a rather close-fitting testa, it is not so tight-fitting but that the seeds have a grayish, rather than a brown-

ish appearance. Since ssp. *montana* regularly has much longer pubescence on the upper part of the peduncles than is to be found in any other of the subspecies, there need be no difficulty in distinguishing it from *glutinosa typica*. In the absence of mature seeds, it is not possible to distinguish ssp. *typica* from ssp. *brevistyla*.

Rydberg maintained that *T. glutinosa* had a longer inflorescence than his "intermedia," and that its pedicels were longer. Nevertheless, he annotated, as *T. intermedia*, several collections such as *Canby 294, J. Macoun 1083*, and *Allen 274*. These plants have inflorescences 8, 9, and 10 cm. long, respectively, and pedicels ranging from 5 to 9 mm. in length, rather than a "short, dense raceme but 1 or 2 cm. long." During the summer of 1942 the writer had an opportunity to observe a small patch of "Tofieldia intermedia" during the interval between June 21st and July 22nd. These plants were growing in a bog 25 miles northwest of Cle Elum, Washington. As the plants started to flower the inflorescence usually was scarcely 2 cm. in length. By the time the majority of the buds had opened the inflorescence had always elongated to from 3 to 6 cm., and when the fruits were mature the length of the racemes was usually from 6 to 10 cm. The pedicels showed a somewhat similar variation, the lower flowers usually having the more elongated flower stalks, some of which were often 8 mm. long. It seems to the writer that Rydberg was misled to his conclusion that "intermedia" had such short racemes because of the fact that he had very little material of that entity which was mature and he was forced to compare flowering material of "intermedia" with plants of *glutinosa* which he had in all stages of development.

Rydberg cited, as the type of *T. intermedia*, a specimen from Sheh-Shock Lake, Alaska, collected in 1895, *M. W. Gorman 78* (Type at the New York Botanical Garden). This specimen is in flower rather than fruit and it therefore cannot be ascertained whether or not the seeds would have had a tight or loose testa — the only diagnostic character that will serve to distinguish ssp. *typica* from ssp. *brevistyla* in all cases. Nearly all collections from northern British Columbia have the testa characteristic of *glutinosa typica*, so it seems reasonable to assume that Rydberg's type may belong with that entity. Rydberg cited several other collections under his *intermedia*, including — Yes Bay, Alaska, in 1895, *J. Howell 1666;* Khantook Is., 1892, *F. Funston 47;* Sitka, *Bongard*. These plants have not been seen. Of the other collections he cited, the first two, namely, Selkirk Mts., 1890, *J. Macoun*, and Totoish Mts., Wash., in 1897, *O.D. Allen 274*, are *T. glutinosa* ssp. *brevistyla*, whereas the other four are *T. glutinosa* ssp. *montana*. Thus it is clear not only that Rydberg's "species" *intermedia* was anything but a natural entity, but that (as shown by his annotations) it included some specimens of the specific entity, *glutinosa* proper, from which he was attempting to separate the western plants. Furthermore, an examination of the material which he annotated shows that he annotated as *T. intermedia* one specimen of ssp. *occidentalis*. Since *T. intermedia* was founded on such a mixture of specimens, and since the type specimen is too immature to be assigned with certainty to any one of the elements here included under *T. glutinosa*, the name cannot be used for any of those subspecies.

b. T. glutinosa ssp. brevistyla ssp. nov.

T. glutinosa (Michx.) Pers., apud Wats., Proc. Am. Acad. **14**:283. 1879, in part (the Oregon plant).
T. intermedia Rydb., Bull. Torr. Bot. Club **27**:528. 1900, in part only, and very probably not as to type.
T. occidentalis Watson, op. cit., in part but not as to type; Rydb. Fl. Rcky. Mts., 147. 1922, in part; Abrams, Ill. Fl. Pac. States **1**:372. 1923, in part; Peck, Man. Pl. Oregon 189. 1941, in part.
T. occidentalis Wats. var. *intermedia* (Rydb.) Peck, loc. cit., in part only.

Planta a *T. glutinosa* ssp. *typica* floribus aliquantum amplioribus, testis seminum laxis, seminibus non fuscis differt.

Much like ssp. *typica*, especially as to pubescence, but the flowers very slightly larger and the seeds with loose testa and therefore not brownish in color.

Type: in moss on floating logs, Blackwater Lake, ca. 32 miles north of Golden, British Columbia, July 11, 1941, at 2150 ft. elev., *Hitchcock & Martin 7638* (University of Washington Herbarium). Isotypes at most of the large herbaria in the United States.

Range: from the Selkirk Mountains westward across British Columbia to southern Alaska and Vancouver Island, southward in the mountains, to southern Oregon.

Representative material (the starred collections are those which have seeds mature enough that they can be seen to have a loose testa, the unstarred collections are in bud or flower only, hence some of them may really more properly belong with the ssp. *typica*): ALASKA—without definite locality or collector* (NY); southern Alaska, *Rudkin* in 1883* (NY). WITHOUT DEFINITE LOCALITY—Cascade Mts., *Newberry** (NY), "T. occidentalis Watson n. sp. Bot. Calif. 1871"* (NY). BRITISH COLUMBIA—Kleena Kleene, *McCabe 549** (C); 25 mi. n. of Barkerville, *McCabe 61a*, with considerable doubt (C); Alta Lake, *McCabe* (C) and *McCabe 2902** (C); Calvert Is., *McCabe 4373* (C); Summit Lake, n. of Prince George, *McCabe 8255** (C); Vancouver Is., Anderson Lake, *Babcock* (CA), Mt. Arrowsmith, *M. S. Baker 849b* (CA), *Carter* in 1915 and 1916 (G), and *Howell 7629* (CA); Comox, *Macoun 5981* (G, NY), Dist. Renfrew, *Rosendahl & Brand 45* (C, G); Glacier, *Prince* (G); Hillier's Swamp, *Carter* in 1915 (G); Chilliwack Valley, *Macoun 54012-014** (G, NY); Selkirk Mts., *Brown 280*, approaching ssp. *montana* (G). *Butters & Holway 575* (G), *Macoun*, July 31, 1890, annotated "T. intermedia" by Rydberg (NY) and Aug. 4, 1890, *Macoun** (NY), *Prince* (G), Roger's Pass, *Shaw 465**, annotated "T. intermedia" by Rydberg (G, NY), and Gold Stream, *Shaw 1083**, also annotated as "T. intermedia" by Rydberg (G, NY).

WASHINGTON—near Granville, *Conard 370* (G, NY); Totoish Mts., *Allen 274**, cited as *T. intermedia* by Rydberg (C, CA, G, NY, W); Marmot Lake, Olympic Mts., *Dickinson 29* (W); Olympic Mts., *Piper 2242* (G); Cascade Tunnel, *Jones* in 1911 (C); Whatcom Co., Mt. Baker, *Curtis* in 1908 (W), *Muenscher 7719* (W), *7720* (NY), *7721* (C), and *10251* (G), and *Thompson 5388*, approaching ssp. *montana* (G); Chelan Co., Lake Wenatchee, *Sandberg & Leiberg 629* (C, CA, G, NY, W); Ice Creek, Entiat Valley, *Morrill 394* (C, W); Mt. Stuart region, *Thompson 5816** (G), *7729** (C, G), and *9569* (NY); Three Brothers, *Thompson 10759* (NY); Kittitas Co., Snoqualmie Pass, *Thompson 7206* (C, G); Teanaway Creek, *Whited 758* (G); 25 mi. nw. of Cle Elum, *Hitchcock 7981* and *8052* (W); near Keelchelus Lake, *Henderson* in 1892* (W); Yakima Co., near Yakima, *Brandegee* (C); Yakima Region, *Tweedy* in 1882 (NY); Skamania Co., Mt. Paddo, *Suksdorf* in 1886, labelled *T. occidentalis* by Watson (G); Pierce Co., Mt. Rainier, *Piper* in 1888* (W), *Grant* in 1925* (CA, W), and *Allen 47*, approaching ssp. *montana* (G);

Clallam Co., Olympic Mts., *Elmer 2504* (NY), Lake Ozette, *C. N. Jones* in 1939* and *Rigg* in 1933* (W) and Thompson 9429 (C, G). OREGON—without definite locality, *T. Howell* (NY) and *E. Hall 532* (G, NY); Mt. Hood, *Barrat* in 1882* (G), *Henderson 811* of 1924* (G), *Keck 325* (C), and *Thompson 5060* (G); Mt. Jefferson, Jefferson Co., *Peck 9141* (NY); Woahink Lake, Lane Co., *Constance* in 1924 (C); Diamond Lake, Douglas Co., *Applegate 4132* (C, G); Crater Lake, Klamath Co., *Cusick 2987* intermediate with ssp. *occidentalis* (C, G, NY).

Most workers have assumed that this is the entity which Rydberg intended to include under *T. intermedia*. However, it seems more probable that Rydberg would have called much of this material *T. occidentalis*, since only two of the several collections he cited under *T. intermedia* belong here. The bractlets below the flowers vary considerably in the degree to which they are connate, so much reliance should not be placed upon this character in delimiting taxonomic entities.

In the southern limit of its range ssp. *brevistyla* intergrades with ssp. *occidentalis* to some extent but there is little reason to confuse plants of northern Oregon and Washington with those from California, since the styles of the latter plants are much the longer. In northern British Columbia ssp. *brevistyla* appears to merge with ssp. *typica*, both in characteristics and range. Unfortunately most of the collections from that region do not have seeds mature enough that the nature of the testa can be used as a criterion for identification, but two collections — Sitka, *Whited 1392** and Mendenhall, *J. P. Anderson 2A376* (both collections in the Anderson Herbarium at Iowa State College) have seeds that are intermediate between the average seeds of ssp. *typica* and ssp. *brevistyla*.

c. **T. glutinosa** ssp. **montana** ssp. nov.

T. intermedia Rydb. l. c., in part.
T. glutinosa (Michx.) Pers. apud Wats., l. c. in part (Wyoming plants)

A ssp. *typica* pedunculis superne pilosis terquater longioribus quam latioribus, basibus latioribus quam apicibus, sepalis ca. 3.5 mm. longis, petalis ca. 4 mm. longis, testis seminum laxis, seminibus non fuscis differt.

Much like ssp. *typica* in all characters, but upper art of peduncles with hairs 3 to 4 times as long as thick, the bases little thicker than the tips; sepals averaging ca. 3.5 mm. long; petals averaging ca. 4 mm. long; seeds with rather loose testa, thus not brownish in appearance.

Type: meadow at Logan Pass, Glacier National Park, Montana, Sept. 18, 1937, *F. A. Barkley and V. L. Marsh 1731* (University of Washington herbarium number 41183; isotype at NY).

Range: southern Canadian Rocky Mountains and southward into Montana, Idaho, and Wyoming.

Material seen (the starred collections were labelled "T. intermedia" by Rydberg): MONTANA—Glacier Park, *Kelley* in 1912 (CA); Lake McDonald, *Umbach 355** (NY); Little St. Mary's Lake, *Umbach 808** (NY); Mary Baker Lake, *Vreeland 1182** (G, NY); Pearson Valley, Glacier Park, *Somes 56** (NY); Cracker Lake, *Maguire 646* (C); Elrod Lake, Glacier Park, *Maguire 647* (C, G); Dawson Pass, Glacier Park, *Somes 34** (NY); Logan Pass, *C. N. Jones 5547* (C, W), *Hitchcock 1908* (CA, G); summit Skalkaho Road, *Kirkwood 1782* (G); Granite, *Scheuber 247** (NY); Kooskooska Meadows, *Kirkwood & Severy 1676* (G); Trapper Peak, Bitter-

root Mts., *Kirkwood 1051* (G). IDAHO—10 mi. w. of Obsidian, Custer Co., *Hitchcock & Martin 5751* (NY, W); 1 mi. e. of Elk Summit, Valley Co., *Davis 2680* (CA). WYOMING—Yellowstone Region, *Richardson* in 1878 (G); Lewis River, Yellowstone Park, *Nelson & Nelson 6382** (G, NY); Taggart Lake, Grand Teton Park, *Williams 1195* (CA); Jenny Lake, Jackson's Hole, *Payson & Payson 2185** (CA, G, NY); Cement Creek, *Tweedy 336** (NY).

These plants can very readily be recognized because of the long pubescence of the upper part of the stem, a peculiarity which, surprisingly enough, Rydberg appears not to have detected. Judging from the material he cited, and from his annotations on herbarium specimens, it is apparent that this is the phase of the plant Rydberg had in mind chiefly when he described *T. intermedia*, even though he included several collections (including the type itself) which do not belong here.

d. T. intermedia ssp. absona ssp. nov.

Planta a ssp. *brevistyla* sepalis et petalis fere emarginatis, petalis ca. 5 mm. longis, sepalis ca. 4 mm. longis, multo latioribus quam petalis, fere cum plus-quam 5-nervis, testis seminum laxis, funiculis brevissimis, fere ad semina non affixis, appendicibus brevissimis, fere non longioribus quam ½ longitudinis seminis, bracteis omnino separatis vel ex parte connatis differt.

Like ssp. *brevistyla* in habit and pubescence, differing as follows: sepals and petals usually emarginate, the petals ca. 5 mm. long, the sepals ca. 4 mm. long, much broader than petals, usually with more than 3 nerves; seeds with loose-fitting testa, the funiculus very short, usually not remaining attached to seed, the appendages of the seeds very short, mostly not so much as ½ as long as the body of the seed; bracts below flowers entirely distinct or but incompletely connate.

Type: Priest Lake, Idaho, August, 1901, *C. V. Piper 3724*, at the New York Botanical Garden. Isotype at the Gray Herbarium. Other material seen — Minard's Bay, Priest Lake, Idaho, elev. 660 m., *MacDougal 287* (NY).

Rydberg annotated the two sheets at the New York Botanical Garden as *T. occidentalis*. It is somewhat surprising that he did this, since the styles of the plants are totally unlike those of true *T. occidentalis*. Macbribe had annotated the sheet at the Gray Herbarium as follows — "Tofieldia absona Macbr. ined. Type." Apparently he decided not to describe the plant as new, so his specific name is being used for the subspecies since they are, by virtue of their retuse perianth lobes and minute appendages, "out of tune" with the rest of the species.

e. T. glutinosa ssp. occidentalis (Wats.) comb. nov.

T. occidentalis Wats., Proc. Am. Acad. **14**:283. 1879, in large part; Abrams Ill. Fl. Pac. States **1**:372. 1923, in large part; Peck, Man. Pl. Oreg. 189. 1941, in large part.

Differing from ssp. *typica* in the following ways — plants somewhat larger, often to 6 or 8 dm. tall; sepals 3.5-5.5 mm. long; styles 1-2.5 mm. long; capsules 5-9 mm. long, the carpels usually free at juncture with styles; seeds with very spongy, free testa.

Type: *Kellogg & Harford 1022*, Mendocino Co., California.

Range: southwestern Oregon to the southern Sierra Nevada Mountains, and along the coast to Sonoma County, California.

Representative of material seen: OREGON: without definite locality — *Howell*, annotated "T. intermedia" by Rydberg (NY); Siskiyou Mts., *Wheeler 2977* (CA); Josephine Co., near Illinois R., *Cusick 2942* (C, G, NY), 4 mi. e. of Takilma, *Keck 4788* (C, CA), Waldo, *Eastwood 2107a** (CA) and *T. Howell 789** (G) and in 1887* (C, NY), 10 mi. sw. of Waldo, *Gale* in 1928 (G), Happy Camp-Waldo Rd., *Lee 1138* (C); near Charleston, Coos Co., *Scullen* in 1926 (C); 4 mi. s. of Mt. Jefferson, *Nelson 2828*, a collection that apparently belongs here, but which is so much out of range that there is a question in the writer's mind as to the accuracy of the label (G). CALIFORNIA—without locality, *Kellogg & Harford 1022*, Type collection, (CA, NY) and *Bridges 360* (NY), Feather River Region, *Head* in 1921 (C); Del Norte Co., Shelley Cr., *Eastwood 12390a*, plants 6.5 dm. tall (CA), Adams Pt., ne. of Crescent City, *Munz 14392* (C), Gasquet, *Eastwood 2244** (CA, G, NY), 10 mi. ne. of Gasquet, *Peirson 3686* (C), Smith River region, *Applegate* in 1927 (C), and Shelley Cr., *Eastwood 12090*, plants nearly 8 dm. tall (C); Humboldt Co., Bald Mt., *Tracy 4606* (C, CA), and *7181* (C); Horse Mt., *Tracy 7664* (C); South Fork Mt., *Tracy 8993* (NY); Sonoma Co., Pitkin Marsh, *M. S. Baker* in 1928 (C); Trinity Co., Scott Mts., n. of Carrville, *J. T. Howell 12729** (CA), near Dorleska, Salmon Mts., *H. M. Hall 8658* (C, CA, G); Trinity Summit, *Manning* in 1899 (C); Siskiyou Co., *Pringle* in 1881 (NY), se. end of Taylor Lake, Salmon Mts., *Carter 1481* (C), Sisson, *Eastwood 1313* (CA), Shackleford Cr., *Butler 1702* (C); Dead Horse Canyon, *M. S. Baker* in 1899 (C); near Big Flat, *J. T. Howell 13371* (CA); Mt. Eddy, *Copeland 3864* (CA) and *3877* (G), *Eastwood 551** (C, G, NY) and *3877* (NY), *Heller 13488* (NY), and *Smith 551* (CA); Mt. Shasta, *Brown 523* and *641* (NY); Calif. Geol. Surv. *1431** (C); near Shasta, *Lemmon* in 1875 (C); Bear Valley Mts., *M. S. Baker 552* (C); Tehama Co., Dry Lake n. of Mineral, *Eggleston 7202* (NY); Lassen Co., Susanville, *Safford** (C); Plumas Co., Gray Eagle Creek, *Bacigalupi 1691* (NY); Little Grizzly Ranger Station, *Eggleston 7599* (G, NY); near Quincy, *J. T. Howell 616* (CA); Gold Lake region, *Sutliffe* (CA); Sierra Co., Sierra Valley, *Lemmon* (C, G); Lusk Meadows, *Sutliffe* (CA); Butte Co., Jonesville, *Copeland 459* (C, CA, G, NY) and *894* (C) and *H. M. Hall 9786* (C, NY); Butte Meadows, *Heller 11654* (C, CA, G, NY); Lake Tahoe Region, near Heather Lake, *Campbell* in 1913 (CA); Velma Lakes, *Jussel* (C); Half Moon Lake, *McGregor 63* (NY); Mariposa Co., Yosemite Valley and vicinity, *Bartholomew* in 1934 (C), *Edwards* in 1871 (NY), *H. M. Hall 9220* (C); near Mineral King, *Eastwood* in 1903 (CA), *Michaels* (CA), and *Schreiber 1932* (C); Inyo Co., near Morgan Pass Lakes, *Peirson* in 1933 (C); Gilbert Lake-Kearsarge, *Austin 367* (C, CA); Morgan Pass, *Peirson* in 1940* (C); Tulare Co., Sequoia Nat. Park, *Derby* (CA); Hockett Meadows, *Hall & Hall 8458* (C); Reflection Lake, *Howell 15895* (CA); Mineral King, *T. S. Brandegee* in 1892 (CA); Alta Meadows, *K. Brandegee* in 1905 (C); Vidette Meadows, *Campbell* in 1916 (C).

Because of its large flowers and slender styles this is the most easily recognized of the different subspecies. It is most similar to ssp. *brevistyla* and intergrades with that subspecies where the ranges of the two plants overlap in southern Oregon. It is debatable whether or not it should be reduced to subspecific rank, but since its seeds are identical with those of its more northern relative, the writer feels justified in according it status as a subspecies. On the whole the material included under ssp. *occidentalis* is quite uniform, but plants from Del Norte County, California, are unusually tall and sturdy, and several of the specimens from Siskiyou County, California, have semi-paniculate inflorescences.

* The starred collections are those with seeds mature enough to show the nature of the testa, i.e. whether loose or close-fitting.

Notes on Geographical Distribution, I—Eleocharis parvula (R. & S.) Link

Charles Louis Gilly

The North American distribution indicated on my 1941 map is, briefly for reference, as follows: coastal Newfoundland; coastal and estuarine eastern statement:

E. parvula (which has also been known in American botanical literature as *E. pygmaea, Scirpus pygmaeus* and *Scirpus nanus*) has a wide distribution in Europe and is said to occur in Japan. The North American distribution of *E. parvula*, based partly on the specimens in the herbarium of the New York Botanical Garden and partly on Svenson's map (5), is shown by crosses on my map (Fig. 1).

The North American distribution indicated on my 1941 map is, briefly for reference, as follows: coastal Newfoundland; coastal and estuarine eastern Canada; coastal New England and New Jersey; interior salt marshes of Wisconsin, Michigan and New York; on the south Atlantic coast near Wilmington, Del., Norfolk, Va., Wilmington, N. C., Savannah, Ga., and Indian River, Fla.; on the Gulf coast near Mobile, Ala., Biloxi, Miss., New Orleans, La., and Galveston, Tex., and just east of the Texas-Louisiana boundary; on the Mississippi River near Baton Rouge, La.; and on the Pacific coast near the mouth of the Klamath River in California, near Aberdeen, Wash., and along Barkley Sound on Vancouver Island.

Since the publication of the statement quoted above, I have given considerable thought to the significance of the geographical distribution of this species; the location of *E. parvula* at or near a considerable number of seaports, which have long been of consequence, appears to be of particular importance in any consideration of the problem. The following tabulation of ideas seems to merit presentation — if for no other reason than to indicate the need for further study of the distribution of the species:

1. The primary distributional area of *E. parvula* appears to follow the North Atlantic arc pattern so characteristic of a considerable portion of the vegetation of northern and northeastern North America; the exact western limits in North America of the primary distributional area are not yet known.

2. The colonies of the interior salt marshes of Wisconsin, Michigan, and New York may either (a) represent residual segments of an actual part of the primary distributional area, or (b) have been established from achenes carried by migratory marsh or shore birds — probably in particles of mud on their

1 Gilly, Charles. 1941—The Status of *Eleocharis parvula* var. *anachaeta* (Torr.) Svenson. Am. Midl. Nat. **26**:65-68.

2 At that time it was shown that the variety *anachaeta* was an aggregate of two species—*E. coloradoensis* (Britton) Gilly and *E. membranacea* (Buckley) Gilly—neither of which could be considered as closely related to *E. parvula*.

feet — from the eastern Canadian coast area. For glaciological reasons the latter explanation seems preferable.

3. The colonies known from New Jersey southward along the Atlantic coast — and perhaps even those along the New England coast — have been established from achenes introduced either (a) by migratory marsh or shore birds following the coastal flyway, or (b) by the dumping, at or near the coastal ports, of ship ballast which originally had been loaded in the European or north-eastern American areas where *E. parvula* grows.

4. The colonies of the Gulf coast region have been introduced from the primary distributional area by either of the two methods listed above for the Atlantic coast colonies. If the introduction was avian in origin, it represents a southward spread along the great Mississippi Valley flyway — somewhat comparable, although in the reverse direction, to that postulated by Freedland[3] for certain species of *Hemicarpha* — from the Wisconsin-Michigan area or from central Canada (providing that the primary distributional area extended so far to the west); local colonies of the species might, then, reasonably be expected in ecologically suitable places along this flyway between the Gulf coast and the Great Lakes.

5. The colonies of the Pacific coast area (and of Japan, if the species actually occurs there) have almost certainly been established from achenes carried in ship ballast as mentioned above. This seems to be the only logical explanation for these colonies unless further exploration and collection yields evidence of a present or a former transcontinental North American extension of the primary distributional area of the species.

NEW YORK BOTANICAL GARDEN,
NEW YORK, NEW YORK.

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3 Freedland, S. 1941—The American Species of *Hemicarpha*. Am. Jour. Bot. **28**:855-861.

Notes and Discussion

Revegetation of the Abandoned Fields of Mammoth Cave National Park

B. B. McInteer

When any farm land was purchased to become a part of Mammoth Cave National Park, the land was left idle. Little effort, if any, has been made to reforest that land which was formerly cleared and cultivated, but within the last few years many species of forest vegetation are seen growing within the old, abandoned fields. Nature is permitted to take its course, for no plants are being cut and no plantings made.

In the summer of 1943 the writer made observations in several fields in that part of the park known as "Joppa Ridge." Most of this particular region was added to the park reservation about 1936 which means that these fields had been undergoing a change for at least seven years. Some of the fields, because of their low productivity, were practically abandoned by their owners even before this date, allowing them to be occupied by native plants that migrated into them.

The fields under consideration are from five to twenty acres in area and are adjacent to or even partially surrounded by a compact growth of forest vegetation containing many species of native trees that are large enough to have been producing fruit all this time. All of the land in this particular part of the park was derived from the Chester (Cypress) sandstone, and consequently is not very fertile. It is low in the essential chemicals and its water-holding capacity is not good. This low productivity is not at all due to the relief, for here, unlike much of the Chester formation, the land is nearly level or very gently rolling, but it is due to the texture of the soil, the deficiency of essential minerals, and to its underground drainage system. The soil is sandy but only a short distance below the surface are layers of limestone (the St. Genevieve) and it is here that, by the action of water in dissolving the material, an extensive underground system of streams has developed. There are no surface streams or well definied valleys in which water might flow. The water—even in rainy seasons—sinks and runs away by means of these subterranean creeks and rivers flowing into Green River which traverses the park.

In this discussion, the plants of these fields and the adjacent woods are referred to by their common names—applied either to individual species or to groups of two or more species of the same genus. Some explanation is necessary about the meaning of the respective common names and this is given in the following list.

Oaks—*Quercus alba* L. (White oak)
Q. borealis Michx. var. *maxima* (Marsh.) Ashe (Red oak)
Q. falcata Michx. (Spanish oak, Southern red oak)
Q. marilandica Muench. (Blackjack oak)
Q. stellata Wang. (Post oak)
Q. velutina Lam. (Black oak, Quercitron)

Hickories—*Carya cordiformis* (Wang.) K. Koch (Bitternut)
C. glabra (Mill.) Sweet. (Black or broom hickory, Pignut)
C. laciniosa (Michx. f.) Loud. (Big shellbark hickory, Kingnut)
C. tomentosa (Lam.) Nutt. (White hickory, Mockernut)

Maples—*Acer rubrum* L. (Red maple, Swamp maple)
A. saccharum Marsh. (Sugar maple, Sugar tree)

Elms—*Ulmus americana* L. (White elm)
U. fulva Michx. (Slippery elm, Red elm)

Ashes—*Fraxinus americana* L. (White ash)
F. lanceolata Borkh. (Green ash)

Walnuts—*Juglans cinerea* L. (Butternut, White walnut)
J. nigra L. (Black walnut)

Sumacs—*Rhus aromatica* Ait. (Fragrant sumac)
R. copallina L. (Mountain, dwarf, or shining sumac)
R. glabra L. (Smooth sumac, White sumac)

Poison ivy—*Rhus radicans* L.

Roses—*Rosa carolina* L. (Pasture rose)
R. setigera Michx. (Prairie rose)

Blackberries—*Rubus allegheniensis* Porter. (Allegheny blackberry)
R. flagellaris Willd. (Dewberry)

Sawbriers—*Smilax glauca* Walt. var. *genuina* Blake. (Common sawbrier)
S. rotundiofolia L. (Greenbrier, Catbrier, Horsebrier)

Grapes—*Vitis aestivalis* Michx. (Summer grape)
V. vulpina L. (Frost grape)

Dwarf hackberry—*Celtis pumila* Pursh. var. *georgiana* (Small) Sarg.
Flowering dogwood—*Cornus florida* L.
Persimmon—*Diospyros virginiana* L.
Juniper—*Juniperus virginiana* L. (Red cedar, Savin)
Black gum—*Nyssa sylvatica* Marsh. var. *typica* Fern. (Sour gum)
Wild black cherry—*Prunus serotina* Ehrh.
Black locust—*Robinia Pseudo-Acacia* L. (False Acacia)
Common elder—*Sambucus canadensis* L. (Elderberry)
Sassafras—*Sassafras albidum* (Nutt.) Nees. var. *molle* (Raf.) Fern.
Tulip tree—*Liriodendron Tulipifera* L. (Yellow poplar)
Coralberry—*Symphoricarpos orbiculatus* Moench. (Indian currant)
Broomsedge—*Andropogon virginicus* L.
White sweet clover—*Melilotus alba* Desr.
Bushclover—*Lespedeza* spp.
Milkweeds—*Asclepias* spp.
Goldenrods—*Solidago* spp.
Quinquefoil—*Potentilla* sp.

No degree of certainty could be felt when trying to determine most of the species of herbaceous genera, for they were not in the proper stage of development. Since it was difficult to determine many species of the woody plants because of their small size, no great effort was made to indicate the relative abundance of the various species of a given genus represented in any particular field. However, in each instance in which two or more plants are mentioned an effort has been made to give the most common ones first.

For the most part these fields were covered to some extent with one or more species of trees as well as shrubs and woody vines. It was evident that the juniper had migrated more readily than the other woody plants, for small individuals of this species were found rather abundant several hundred yards from the nearest mature tree of its kind while the oaks, hickories, and walnut seedlings were not so far from the parent plants. One might expect the species having winged seeds such as maples and ashes to have invaded the region very readily but such seemed not to be the case. Nor could the writer see that they had gone much farther—if any—into these old fields than had the species with larger and heavier seeds. Those species with fleshy fruits, such as juniper,

sumacs, grapes, sassafras, and persimmon are distributed over a wider range than are the species with heavy seeds or even those with winged fruits or seeds.

The following table lists a few representative trees and shows how they vary in the fields and the adjacent woods under consideration.

Name of tree	No. fields in which species was found	No. woods in which species was found
Those with fleshy fruits		
Juniper	5	4
Dogwood	1	1
Black gum	0	3
Those with winged fruits or seeds		
Ashes	2	2
Elms	1	1
Maples	0	4
Tulip	0	1
Those with nut-like fruits		
Hickories	2	4
Oaks	1	4
Walnuts	1	2

The above table reveals the fact that black gum, maples, and tulip are absent from these old fields yet are well represented in the wooded parts. In an explanation for this condition one might advance the idea that maples and tulips are lacking in the fields because the land is too poor to support their growth, for they do require an excellent soil, but this does not explain the cause for the absence of black gum, for it thrives on poor soil and there it may even become the dominant plant. While animals are the agents which disseminate nuts and fleshy fruits, they operate only in those cases in which they use the structures, wholly or partially, as a food. Perhaps birds and other animals do not feed upon the fruits of black gum since it is common in the woods and lacking in the fields. The same thing may be said concerning flowering dogwood, for it is extremely rare in the fileds, yet common in the woods. The fruits of these two trees are similar in their properties and are often referred to as "sour," "acid," "bitter," and "astringent."

There are a few fields which are absolutely free of all of these woody plants. The seeds of some of the species, no doubt, were transported into these fields, for many large trees are near. The only explanation suggested is that the seedlings could not thrive there, for the entire surface has been compactly covred with a tall growth of broomsedge.

In many cases, these fields, when under cultivation, contained a growth of sassafras, persimmon, blackberries, and sawbriers of varying compactness and relative abundance. Such conditions of woody plants existing as "weeds" are rather common in many sections of Kentucky, especially those parts in which the farm practices are not modern and the land infertile. As a usual thing the trees that are near these fields are not sufficiently large nor is the growth compact enough to prevent the growth of juniper and other plants that have a high light requirement. The farmers in that particular area kept the trees cut for fuel, fences, railroad ties, and lumber as soon as they became large enough to serve those purposes and this cutting prevented the formation of a forest growth sufficiently dense to shade out those plants that are intolerant to low light intensity.

The following are some specific cases in which notes were taken on observations made during this survey. 1. A field near Cedar Sink having an area of about four acres is surrounded by a forest growth mainly of juniper, oaks, tulip, hickories, walnuts, dogwood, and maples. Within the field are scattered specimens of juniper, common elder, wild grapes, sumacs, persimmon, sassafras, and walnuts. All of these plants were less

than six feet tall. This field is not on the highest part of Joppa Ridge and it differs from the others in that the soil is more productive.

2. A long, narrow field bounded on both north and south sides by a forest growth of hickories, ashes, elms, juniper, and black gum contained scattered specimens of the following woody plants: sumacs, ashes, hickories, sassafras, juniper, blackberries, roses, elms, and dwarf hackberry. All of the specimens within the field were less than six feet tall. The herbs most commonly present were broomsedge, goldenrods, and quinquefoil. The woody plants were much more compact and the herbs correspondingly less compact on the south side than on the north side of the field. This difference was due either to the direction of the wind, which was generally from the southwest, or to the influence of the shade of the forest trees, or both. Those trees on the south side supplied more seeds to the field and they also protected the seedlings by serving as a wind-break and by shading to some extent.

3. A large field bordered on the north side only by a forest growth composed mostly of oaks, hickories, maples, black gum, walnuts, juniper, sumacs, and ashes, supported a compact growth of oaks, ashes, juniper, sassafras, sumacs, hickories, black locust, blackberries, roses, and sawbriers. Apparently this field had been abandoned even before that land was purchased, for many individual plants were more than ten feet tall. There was practically no growth of herbs. This condition is the result of the dense shade produced by the larger plants.

4. An area which is the central part of a large field with the nearest mature tree—an oak—more than a hundred yards away, contained woody plants which were widely separated. They were juniper (all under four feet in height), persimmon, sumacs, coralberry, blackberries, and sawbriers. The seeds of all these plants are produced within a fleshy fruit and were, no doubt, scattered over a wide area by birds. There was also a compact growth of goldenrods.

5. Within a field of ten or twelve acres entirely surrounded by a forest growth of oaks, juniper, hickories, maples, and black gum were found persimmon, juniper, sumac, flowering dogwood, wild grapes, sawbriers, poison ivy, anad wild black cherry. All species except persimmon were rather rare. Persimmon, no doubt, was growing in the field when the land was purchased in 1936, for many individuals were more than ten feet tall, indicating that they were more than eight or ten years old.

A very interesting phase of the vegetation is the compact growth of white sweet clover along the sides of the roads all of which are made with crushed limestone. Here and only here, a compact and luxuriant growth of this legume was noticed. This limitation is due to the fact that the soil away from the road is too acid for such a plant. The mere use of the roads, too, helps in the scattering of the seeds of this plant. Much of the land is covered with a compact growth of bushclover. These two legumes, in time, because of their influence on the nitrogen content of the soil, will be shaded out by woody plants which will thrive as a result of the reaction of these herbs. A change in the vegetation of these old fields, because of their infertile soil, involves more than mere migration and germination of the seeds. Before much of the land can produce a good growth of oaks, hickories, and maples the soil must be made more fertile by the influence of the plants present. Therefore, the succession, in many cases, may continue for more than a century before the climax appears.

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Longevity of Captive Wolverines

Gordon T. Woods

There are few data on the life span of the wolverine, *Gulo luscus* (Linnaeus). The following information was obtained through correspondence with zoological parks, six in the United States and one in Canada. Of the 57 wolverines reported, 43 were shipped from Cordova, Alaska. Four others came from Alaska, two from extreme northern Minnesota, one from Yellowstone National Park, and the locality of origin for six is unknown. These reports show that duration of captivity varied from about three weeks to fifteen years. The average length of life of 45 wolverines surviving more than six months was about five and one-half years.

The most nearly complete record is that of five animals in the St. Louis Zoological Garden. They were received on January 10, 1929, as "young animals," probably less than one year of age, from Cordova, Alaska. One of these wolverines, a male, died in April, 1943, but the others are alive and are now close to sixteen years old. Another long record is that of the fifteen-year old male now on exhibit at the University of Michigan. This wolverine was obtained from Dr. William H. Chase, of Cordova, by the Detroit Zoological Park, on March 23, 1930, and exhibited there until October 1, 1939, when it was transferred to Ann Arbor.

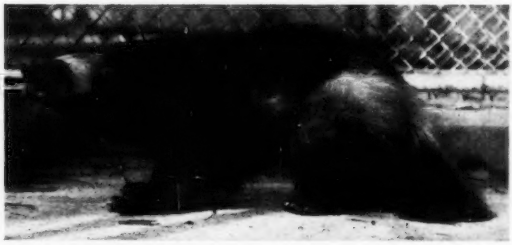

Fig. 1. A 38½-pound male Alaskan wolverine, *Gulo luscus* (Linnaeus), in the Museum's Zoo at the University of Michigan. It has lived 14 years in captivity. Photograph by Leroy Berge.

A large number of wolverines have been successfully exhibited at the Detroit Zoological Park; 27 records came from there. John T. Millen, Director of the Zoological Park Commission, attributes this success to proper feeding as well as regular cleaning and fumigating of the exhibit. Sixty-three per cent of the animals died in the winter and spring seasons. In general, the records show that the animals have not been able to adapt themselves to captivity. The causes of mortality among captive wolverines may be many. Autopsies at Detroit indicate that infections of the teeth and throat are the primary causes of death among adults. In other instances, tuberculosis and disturbances of the digestive tract were given as causes. A small number of the animals arrived at the parks in poor condition and consequently died soon afterward. High summer temperatures have restricted the exhibition of these animals in the National Zoological Park at Washington, D. C. Fighting which follows the introduction of new individuals into the wolverine pens sometimes results in mortality. Feeding practices, sanitation, housing conditions, and old age are factors which undoubtedly affect the period of longevity. Variations in temperature of the region in which exhibited, area of the exhibition pen, and locality of origin may tend to influence survival.

It is evident from the available records that wolverines may live fifteen years in captivity. They are exposed to many factors which restrict the average length of life, in captivity, to about five and one-half years. I am grateful to the zoological organizations which contributed information, and to members of the faculty of the University of Michigan for assistance in the preparation of this manuscript.

ANN ARBOR, MICHIGAN.

Book Reviews

AN OUTLINE OF GENERAL PHYSIOLOGY. By L. V. Heilbrunn. W. B. Saunders Company, Philadelphia and London, 1943. Second Edition. xii + 748 pp., 44 tables, 135 figs. $6.00.

This stimulating and informative book was written to provide students with a textbook dealing with general physiology as Dr. Heilbrunn would like to define the field, but it is so well written and so satisfying in its abundance of detail and interpretation that its usefulness extends far beyond the classroom. Everyone who is familiar with the modern textbooks of "general" physiology realizes that the field has not yet become stabilized, and that opinions as to its nature and content are widely divergent. It seems to be agreed that the subject concerns itself with the physics and chemistry of the organism, with particular reference to the cell, but here agreement stops. Emphasis ranges in the textbooks from physical chemistry and its application to cell structure and activity to what Dr. Heilbrunn terms "dilute mammalian physiology." The author is not satisfied with either of these extremes and, in stating his point of view in the first chapter, reminds us that the general phyiologist seeks to understand the ultimate mechanisms underlying life processes, the "nature and mechanism of living matter." Inasmuch as the cell is the unit (with certain reservations) and life must be interpreted in terms of cells, the author holds with the opinion expressed in the preface to Verworn's first edition, that general physiology becomes cell physiology. The greater part of the book, therefore, is devoted to the fundamental functions of cells and the general characteristics of living substance. Dr. Heilbrunn draws his material from all phases of biological science in an attempt to summarize our present knowledge of these general characteristics.

The plan of the book is very logical. Chapters II to XIII deal with what the author calls the "statics" of living systems. The second chapter is concerned with the morphology of living cells, the next five with their chemical nature. These include rather brief chapters on proteins, carbohydrates and lipids, an excellent chapter on the identification of chemical compounds in protoplasm, and a chapter on the hydrogen ion concentration of protoplasm. Chapters VIII to XIII take up the physical properties of living systems, viz., optical activity, viscosity, colloid chemistry, the protoplasmic surface, osmotic relations and membrane permeability. For organization and clarity, the chapters on membrane permeability are outstanding in the field. Beginning with the fourteenth chapter, attention is turned to the kinetics of living systems, first, in Chapters XIV to XXIII, to the chemical aspects (food requirements, digestion, absorption and assimilation, growth, respiration, intermediary metabolism, secretion and excretion), then, in Chapters XXIII to XXX, to the physical aspects (energy exchange, movement, production of electricity and light). In Chapters XXXI to XXXIII the author considers the environmental conditions under which living matter must function (temperature, pressure, light and chemical factors), leading through a discussion of acclimatization (Chapters XXXIV) to irritability, the various phases of which he takes up in Chapters XXXV to XL (the irritability concept, general characteristics of the irritable process, theories of stimulation and anesthesia, conduction, tropisms and receptors). Following these are a chapter on age and death, and a concluding chapter on reproduction, with emphasis on the nature of cell division.

In seeking to restrict his outline to those aspects of physiology which are more directly applicable to the cell itself (the "least common denominator of living processes"), Dr. Heilbrunn has omitted or has made but passing reference to a number of subjects which one usually finds in physiology textbooks. Blood pressure and flow, capillary filtration, transport of oxygen and carbon dioxide, the coordinating action of the nervous system, the mechanics of excretion and regulatory mechanisms are among the "missing" topics, for which the reader is usually referred to textbooks on mammalian physiology. The "omissions" were made purposely, of course, and are quite consistent with the author's view that general physiology is cell physiology. If the two are synonymous, these topics might well be considered as being beyond the scope of the book. However,

although it is true that our knowledge of coordination, circulatory mechanics and the rest is based largely on conditions in the vertebrates, and therefore may be considered rather specialized, surely the basic problems confront most other forms of life in one way or another and perhaps for that reason could be included in the field. No matter how much we know about the cell as an individual, we are hardly going to be able to understand life as it is lived by the multicellular organism until we know how its constituent cells act together as a unit. Of course, such a point of view is not in accord with the idea that general physiology and cell physiology are identical, but perhaps they are not. As has been suggested by other authors, it might be advantageous to call cell physiology just that—cell physiology, and to consider it one phase of the broader study of function, reserving the term "general physiology" for that field which would consider all functions of which living matter is capable, either as individual cells or as multicellular organisms. Even such a specialized function as temperature regulation might be considered as part of general physiology, not as an accomplishment of the higher mammals, but as another manifestation of the many functions which living matter is able to carry on. Then cell physiology, organ physiology, plant physiology, mammalian physiology (including "dilute"), insect physiology and so on could be considered as specializations of the general subject, each branch contributing to and selecting from the general field the facts and theories peculiar to it. Unfortunately, the practical difficulties attendant upon an attempt to consider the functioning of higher plants and higher animals in the same course appear to be so great that it would be no simple matter to discuss either above the elementary level in an undergraduate course. In this we find a strong argument for Dr. Heilbrunn's definition of the field.

Most biologists will doubtless find the book quite valuable for their own use. It is essentially a review article on a grand scale, including practically the entire field, all very well coordinated. There are about four thousand literature citations, over half of which are new (since the 1937 edition). One can use it as a starting point for reading into an area new to him and find suggestions for further reading in almost any direction. Important research methods and equipment are described in considerable detail. It is written in a very mature manner, and the author does not hesitate to offer criticism of research techniques and interpretations, or to provide interpretations of his own where needed. There are many tables of useful biological data, among which are life spans, oxygen consumptions, osmotic pressures of body fluids and a series of G values of some of the inorganic salts used by biologists. A comprehensive index of 53 pages is not the least of its virtues. The chapters on environmental conditions and acclimatization should be of particular interest to the ecologist, and the biologist who is doubtful of the universal applicability of mathematics to biological processes will be pleased to find vigorous support in the discussion of the theories of excitation. The philosopher, too, will find food for thought in some of the difficulties which arise in the attempt to define such terms as "stimulus."

One of the most important parts of the book is the author's treatment of the "clotting" effect of calcium on protoplasm and the "calcium release" theory. His applications of this theory to such unsolved problems as muscle contraction, stimulation and anesthesia, conduction, heat death, cold death, histamine release and cell division are very interesting and in many cases quite convincing. After considering the various theories of stimulation, for example, Dr. Heilbrunn reviews experiments which show that when a cell is stimulated the cortical cytoplasm is liquified while that of the interior becomes coagulated, and that these changes are associated with a release of calcium from its bonds in the cortical region and a subsequent movement of the ion into the interior. On the basis of these reactions he is able to offer reasonable explanations not only for the experimental results which are in accord with the popular permeability theory, but for those for which the permeability theory is unsatisfactory (e.g. magnesium anesthesia, heat anesthesia and the occasional stimulating effect of anesthetics).

As a textbook it has quite a number of unusual features. In addition to striking out in a new direction so far as subject matter is concerned, it is written from a point of view somewhat different from that apparent in the background of the usual textbook. The author does not content himself with a presentation of the facts, theories and relationships alone, but attempts to give the student an insight into research methods,

the main lines of current investigation and the status of modern theories. The student is soon made acquainted with the fact that research workers sometimes make errors of observation and interpretation. In fact, with his frank appraisals of experimental work and schools of thought, Dr. Heilbrunn hopes to teach the student to weigh evidence for himself before accepting even the most well-recommended theories. Wherever possible he has given authority for every statement. This constant reference to the literature should certainly cause the student to realize that the subject is the product of countless hours of experimentation and thought by thousands of investigators, and that we are only at the beginning. Such an approach should prove to be very stimulating to the serious student, but it certainly does not make it an "easy" textbook, for the author makes rather heavy demands upon the reader's preparation and ability. The discussions are usually quite brief, and it is assumed that the student has a fairly broad background in biology and chemistry (including physical chemistry), but those who may have felt that longer discussions and more background material would have been desirable in the first edition will find that these sections have been expanded to a considerable extent in the present one. This edition is certainly worthy of the best efforts of good students, although some of the chapters may still prove to be rather heavy going for the undergraduate of not more than average ability, industry and preparation. It could hardly be otherwise, however, in a single volume dealing with matters so near the limits of our present knowledge.—WILLIAM A. SPOOR, University of Cincinnati.

FOREST TREE SEED OF THE NORTH TEMPERATE REGIONS WITH SPECIAL REFERENCE TO NORTH AMERICA. By Henry Ives Baldwin. Chronica Botanica Company, Waltham, Mass. 1942. 240 pp., 28 illus. Buckram, $4.75.

Curiously enough, the scattered knowledge of the seeds of almost any crop has never been presented in book form. *Forest Tree Seed* is, therefore, a timely book that fortunately contains a wealth of information on tree seeds especially those of North America.

The first five chapters deal with the structure and development, the production, origin, collection, extraction and cleaning of seed. The factors that influence tree seed production are considered to be age and vigor of a tree, environmental conditions and adaptability to site. Weather is considered to exercise the deciding impulse on crops of seed. The effect of origin of seed on the subsequent development of plants is stressed as being of primary importance to forestry. Evidence of its importance is traced from the 18th century in Northern Europe to the present time. The author points out that the greater part of the tree seed sold privately in America is of unknown origin but that an appreciation of the importance of origin is growing rapidly. Specific directions for seed collection, though brief, are so definite and clear that the inexperienced collector will find Chapter 4 a valuable guide. Chapter 5 covers the extraction and cleaning phases in considerable detail and presents a number of excellent illustrations of extractors, dewingers, dryers and cleaners used in preparing tree seed for commercial use.

Chapters 6 to 12 inclusive are concerned with the storage, longevity and biotic enemies of seeds, internal and external factors affecting viability and the chemistry of seeds and germination. The author points out that the irregular seeding habits of many trees make proper storage of seeds necessary. Furthermore, man cannot depend on natural seeding for forest reproduction. On the other hand, storage is considered inadvisable under several conditions. Natural storage is briefly described and the requirements for artificial storage to maintain vitality are discussed in some detail including the effect of light, temperature, pressure, moisture and the methods of extraction and cleaning. The storage may be either dry and cold simulating conditions in the cone or dry fruit, or moist and cold simulating conditions in the forest litter and humus. The more common biotic enemies of seeds are listed as mammals, birds, insects and fungi. The use of insecticides to prevent injury, and of seed disinfectants to control seed-borne organisms that injure germination is discussed and specific directions are given. The author defines germination as occurring "when the tip of the radicle has elongated far enough beyond the seed coat to show a normal growing tip and give indications

of developing into a healthy seedling." He discusses false and abnormal germination in nature and the tendency among many kinds of seed to exhibit an especially rapid germination in the spring of the year. Internal factors affecting germination are listed as (1) degree of maturity, size, weight and age or condition of reserve foods and enzymes, (2) dormant or rudimentary embryos (3) impermeable seed coats, (4) combinations of two or more factors and (5) secondary dormancy induced by external conditions on germinable seeds.

Methods of treating dormant seeds are described briefly, including scarification, exposure to low temperatures, stratification and exposure to light and to solar radiation. The need for or influence of temperature either constant or alternating, of oxygen and carbon dioxide and of light on germination is stressed. The relation of hormones to germination is considered as only meagerly explored but of sufficient importance to warrant further investigation. The chemical constituents of seeds and their changes during the process of germination, after-ripening, loss of vitality and in germination are treated in a brief but effective manner. Chapter 12 deals with physical and chemical stimulation which is considered to be any action that is directly stimulating to the living cell rather than merely hastening the natural processes of germination.

The remaining 8 chapters of the book deal largely with seed testing which involves determination of origin, purity, vitality and relative freedom from insects and organisms that cause disease. Techniques and procedures are given for sampling, for determining ripeness, percentage of moisture and of empty seed and for the calculation of 1,000 seed weight. Of special interest to the layman are some of the methods outlined for determining seed viability without germination. Among these are the cutting test, the oil test, the embryo ratio method, flotation tests and the weight and volume test. Practices that may be used effectively in a seed laboratory to measure viability are also clearly described and illustrated.

Each chapter is accompanied by a valuable list of references, whereas a 16 page glossary of tree seed terms frequently accompanied by equivalents in other languages is appended at the end of the book. Seed technologists, nursery men, seed collectors and foresters will find this book a valuable addition to their libraries and wish that equally authoritative works on seeds of other crops may soon follow.—R. H. PORTER, Seed Laboratory, Iowa State College.

TERTIARY PRAIRIE GRASSES AND OTHER HERBS FROM THE HIGH PLAINS. By Maxim K. Elias. Geological Society of America Special Papers Number 41, New York, 1942. 176 pp., 17 pls., 1 fig. $1.50.

Fossil *Gramineae* are so rare that accurate information on even the most fragmentary material is of great value to those interested in the living members of the family. This gives a unique significance to the extensive record which Elias has accumulated from the High Plains region sloping eastward into Kansas and Nebraska from the Rocky Mountains.

The deposits of this area have yielded a wealth of material enabling paleontologists to reconstruct the evolution of mammals as the Tertiary forests gave way to the grasslands, and they contain also a remarkably good record of the herbaceous plants culminating in the present flora. Since 1927 Elias has collected material here, and he is now able to present a vivid picture of certain portions of the ancient vegetation and the series of changes occurring from the Middle Miocene to the present, unbroken except in the Pleistocene.

The collection includes a few species of the *Boraginaceae* and a few of the grass tribe *Paniceae*, but the major portion of the study is centered in the grass tribe *Stipeae* In these tribes of grasses the caryopsis is permanently surrounded by a siliceous shell composed of the indurated lemma and palea, and the preservation of this shell is so good that even minute details of external sculpturing are visible. No vegetative parts of the plants have been found. The material, such as it is, is abundant, and there is

little room for the charge so often placed against studies of this kind that they are based on too few individual specimens.

Critical taxonomists have long recognized the grass tribe *Agrostideae* as scarcely more than a convenient catchall for a large assemblage of genera having one-flowered spikelets but representing several phyletic lines; and the sub-tribe *Stipeae*, consisting of *Stipa, Aristida, Oryzopsis, Nasella, Piptochaetium*, and possibly a few other genera, has been set apart as one of these natural groups. The geological record from the High Plains strongly supports this treatment and points to the evolution of the present genera from a small and generalized type, thus far undiscovered, which was the ancestor of the fossil genera *Stipidium* and *Berriochloa* of the Miocene.

It is admitted that the family tree of the group is reticulate, but it is still possible to detect from geologic evidences some definite trends in its evolution, and these generally substantiate the conclusions drawn from comparative morphology and from the ecological picture.

The fossil fruits of the Miocene *Stipeae* have no awns, but the truncated tip of the lemma seems to indicate that there was a fragile, disarticulating awn, no fossil trace of which has ever been found. This disarticulating awn apparently follows through, with slight modification, to living species of *Oryzopsis, Nassella*, and *Piptochaetium*. In modern *Stipa* the awn has become strongly indurated; it remains more or less differentiated at its place of attachment at the tip of the lemma but does not disarticulate. The highest specialization has been reached in *Aristida*, in which the awn has become divided into three parts and traces of the articulation have largely disappeared.

In spite of the way in which the callus and the hygroscopis awn of the lemma of *Stipa* often work together as a self-planting device, these are believed to have evolved independently. Both serve as organs of dispersal, but their remarkable teamwork in some species is regarded as only incidental.

Correlated with this interpretation of the *Stipeae*, based upon the geologic record, are certain morphological differences occurring in living members of the tribe at different levels of specialization. These illustrate such tendencies as the disappearance of the mestome sheath, the concentration of the green mesophyll into sheaths around the veins, the insertion of small secondary veins between the large ones, and the loss of the median lodicule of the flower.

As a basis for the interpretation of the structures under consideration the paper includes a concise treatment of the general morphology of the *Gramineae*. This brings together much interesting material which cannot be found in any other one place, and the inclusion of the voluminous literature published in Russian, the author's mother tongue, will be especially appreciated by students of grass morphology. It is evident, however, that here the author is not exactly in his element, and some inaccuracies must be pointed out.

A considerable portion of the discussion of the *Stipeae* is centered around the *callus*, the hard, more or less sharp, bristly point at the lower end of the hull of the fruit, and this calls into question the morphology of the structure. The callus in grasses in general has been variously defined as the lower end of the lemma, a portion of the rachilla, or a combination of the two, and it is evident that, in a broad sense, it has no exact morphological identity. Elias regards the callus of the *Stipeae* as simply a portion of the rachilla, the lemma being in no way concerned in its structure. This may ultimately prove to be the case, but it is by no means demonstrated at present. The exact manner in which a leaf is attached to its axis and the extent downward to which it affects the structure of the axis is a question too involved to be dismissed on the basis of the superficial evidences which he cites. To answer the question correctly it would be necessary to study at least the course of the stele and lemma traces within the callus, the development of the lemma from the time of its separation from the apical meristem, and the development of the abscission layer.

Elias interprets the callus as approximately the equivalent of the sharp splinter *(assula)* formed when a vegetative branch is torn from the main stem, but this comparison seems to be decidedly overdrawn. Good morphology will certainly question his statement (p. 35) that "the edges of the lemma are always separated by a gap at the base because they do not correspond to the edges of the leaf sheath but to the ruptured

edges of its central part." His general concept of the homologies of lemma, palea, and prophyll, cited in suport of the assula theory is obviously confused, as indicated by the inconsistencies of such statements as the following, the italics being my own:

"The prophyll is the first leaf on each lateral shoot—." (P. 30).

"The homology of the palea with the prophyll of the lateral shoot is well established." (P. 37).

"In the sequence of insertion *upon the rachilla* the *palea* comes slightly above the lemma and inside the latter—." (P. 37).

"The lemma is justly considered to be homologous with the leaf of the axis, and the palea with *a subtending prophyll of a lateral branch*." (P. 35.)

In discussing antidromy in the grass stem, Elias has been misled by one or more of the earlier reports. It is true that successive leaf sheaths on a culm alternate in their direction of overlapping, giving to the erect stem a puzzling morphological dorsiventrality; and individual plants may be designated as dextral or sinistral according to the direction of overlapping of the sheath of the first leaf; but Macloskie's report of a correlation of this right-and left-handedness of the corn embryo with the position of the grain in the right or left of a pair of rows carries a plausible generalization too far. Simple observation of seedlings grown from grains from recorded positions shows that whether an embryo is right-handed or left-handed in this way is purely a matter of chance.

To point out these errors is not in any way to discount the general value of the study. It serves, rather, to emphasize the difficulty of the problem. The grass family is large and complex, and no one person could hope to be versatile enough to speak with the wisdom of the specialist on the various aspects of morphology, cytology, ecology, and stratigraphy involved in a problem of this scope. It is only when the best efforts of all are finally put together that we can hope for stable results.

The fossil species on which the study was based are described in full detail and illustrated with good photographs. There is a step-by-step account of the probable evolution of the herbaceous flora of the region from the Miocene to the present and a brief account of the stratigraphy of the formations in which the fossils occur.—PAUL WEATHERWAX, Indiana University.

CEANOTHUS. Part I, Ceanothus for Gardens, Parks and Roadsides. By Maunsell Van Rensselaer. Part II, A Systematic Study of the Genus Ceanothus. By Howard E. McMinn. A Publication of the Santa Barbara Botanic Garden, Santa Barbara, California. 1942. xii + 308 pp., colored frontispiece, 5 plates, 104 figs., 7 maps, 4 charts, 2 tables. $2.50.

As Major General William Lassiter points out in his preface, "The genus *Ceanothus*, commonly known in California as Wild Lilac or Buckthorn, is one of those singular groups of plants which captivates the imagination of botanist and gardener alike." That this statement is no false claim is amply borne out by this "symposium," both parts of which are accompanied by shorter contributions, viz., Part I by a chapter on *Propagation and Cultivation* by Alfred J. Stewart and Part II by a chapter entitled *The Distributional History and Fossil Record* by Herbert L. Mason. Private support was given by the Pacific Zone members of the Garden Club of America and various interested individuals, all of whom contributed generously to the research fund, known as the Helen Stafford Thorne Ceanothus Project, which enabled the director of the Santa Barbara Botanic Garden to publish this volume (see p. ix). The net result is a valuable addition to botanical and horticultural knowledge and literature, setting a high standard for similar large scale cooperative studies.

The present popularity of various old and new horticultural forms of Ceanothus in America is a good example of the growing interest of the public in native plants. In recent years more than twenty-five noteworthy Ceanothus collections were assembled on the Pacific Coast (p. 9), the first of which was begun in 1923 by Professor Howard E. McMinn. In 1935 this collection was transferred from Mills College to the Santa Barbara Botanic Garden, where extensive horticultural studies have been carried on ever

since. No more suitable place for this work could have been found than the Santa Barbara region wiith its twenty-two native Ceanothus species and varieties. Significantly the horticultural information, largely obtained there and detailed in Part I (pp. 1-128), pertains mainly to the American species, varieties and hybrids, the varieties originated in Europe being listed on pp. 113-114 (none grown on Pacific Coast).

Part II (pp. 130-303) represents Prof. McMinn's mature views of the taxonomy of the genus Ceanothus as acquired by him during nearly twenty-five years of almost uninterrupted study. Included in this treatment are fifty-five species, twenty-five varieties, eleven named natural hybrids, and several minor variations. On the basis of the present distribution of species California is regarded as "the center of distribution," e.g., "the region in which a genus attains its greatest development." Cytologically the genus is characterized by "the regularity in number and behavior of the chromosomes during reduction" (twenty-two species and two varieties have a diploid number of 24 chromosomes, as counted by Mr. M. A. Nobs), a fact which "would seem to indicate that there is no evident cytological barrier to the production of hybrids." Hybridization is apparently important in this genus, although present evidence is still incomplete in several instances (see charts 3 and 4). The author is also of the opinion that experimental (genetical and transplant) studies would reduce the number of recognized species. The distribution, past and present, of the (16 known) fossils and living species as well as their migrations are ably discussed in the chapter appended to Part II. Phylogenetic conclusions are drawn but stated without finality.

The pleasing appearance of the book, its fine typography and excellent illustrations will be appreciated by all readers alike.—THEO. JUST.

SEVEN SCORE BIRD SONGS. By William Bacon Evans. Christopher Publishing House. 1943. 258 pp. $3.50.

William Bacon Evans is not a poet of the first order, surely. Most of his subjects deal with wholly conventional subjects in merely conventional ways. His "Seven Score Bird Songs," however, possess genuine originality and piquancy, and are well worth the reading for any bird lover. Each of these 140 amazingly varied poems is a concise character sketch of a bird species to be found in the Eastern United States. In most cases Mr. Evans includes in the poem a rendering or imitation in words of the typical song or call of the bird in question, and these renderings are almost uniformly striking in their suggestion of the actual sound of the song or call, and pleasing in their fidelity to what seems to be its spirit. Even the casual listener would surely recognize, "Oh come Home! Home! Home! Home!" as the call of the mourning dove. "Drink your tea!" seems to me excellent for the towhee, and "Cluck glee" for the cowbird. For some of his renderings Mr. Evans acknowledges his debt to William Cullen Bryant, John Burroughs, Henry Van Dyke, and others. A few of the songs he wisely hasn't tried to transliterate at all, contenting himself with shrewd observation of color, food, nests, and conduct—details of which appear in many of the poems, often delightfully phrased. Here are a few examples:

Lichens hide my thimble-nest,
Twin white pearls adorn it now.
(Ruby-throated Hummingbird)
Stand a moment like a crooked tree
(Great Blue Heron)
A bombshell bursting at thy feet
(Woodcock)
A downward twirl,
An upward dart
(Black and White Warbler)

All in all, I believe that these poems will give the man or woman who knows and loves birds a real added interest in recognition and observation of them, and especially in listening to their songs and calls. I wish that the "Seven Score Bird Songs" might appear in a separate volume, with black and white drawings as characteristic as the poems themselves. Such a book would be a real treasure to the bird lover.—JOHN T. FREDERICK, Glennie, Mich.